STUART WELLER

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New York State Museum

JOHN M. CLARKE, Director

Museum bulletin 135

GEOLOGY OF THE PORT LEYDEN QUADRANGLE, LEWIS COUNTY, N. Y.

BY

W. J. MILLER

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New York State Education Department
Science Division, September 24, 1909

Hon. Andrew S. Draper LL.D.

Commissioner of Education

SIR: I have the honor to transmit herewith for publication as a bulletin of the State Museum, the manuscript of a report on the *Geology of the Port Leyden Quadrangle, Lewis county,* prepared by Prof. W. J. Miller, a member of the staff of this division.

Very respectfully

JOHN M. CLARKE
Director

State of New York
Education Department
COMMISSIONER'S ROOM

Approved for publication this 24th day of September 1909

A. S. Draper

Commissioner of Education

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New York State Museum, Albany

JOHN M. CLARKE, Director

Museum Bulletin 135

GEOLOGY OF THE PORT LEYDEN QUADRANGLE, LEWIS COUNTY, N. Y.

BY

W. J. MILLER

INTRODUCTION

The Port Leyden, New York, quadrangle of the United States Geological Survey comprises the region lying along the western border of the Adirondack mountains and is included between latitude lines 43° 30′ and 43° 45′ north and between longitude lines 75° 15′ and 75° 30′ west. The map covers 1/16 square degree or about 215 square miles of territory, all of which lies in Lewis county except a few square miles extending into Oneida county at the extreme southeast. The Rome, Watertown and Ogdensburg Division of the New York Central Railroad traverses the region from north to south through the Black river valley. Port Leyden, Lyons Falls, Glenfield, Martinsburg, Turin and Constableville are the principal villages.

This region, like most others along the border of the Adirondacks, was at one time a dense forest which has nearly all been cut away, leaving only small wooded areas of second growth. Next to agriculture, the chief industry is the manufacture of wood pulp and paper, the largest mills being located at Lyons Falls, Goulds Mill, Kosterville, Shuetown, Lyonsdale and Port Leyden. The logs used are driven down Moose river. A number of small sawmills are still in operation.

On the east side of Black river the soil is nearly always sandy and rather unproductive, while on the west side of the river the soil is usually rich and supports a prosperous farming community. The principal products are milk and cheese.

GENERAL GEOLOGIC FEATURES

Under this heading it is proposed to briefly outline the geologic history of the whole Adirondack region so that the detailed study presented in this report may be made more intelligible to the reader. This outline is based largely upon the admirable treatises of Prof. H. P. Cushing.

So far as known the oldest rocks of the Adirondacks are those of Grenville (Precambric) age. They are sedimentary rocks, originally shales, sandstones and limestones, which have been highly metamorphosed into gneisses and crystalline limestone. These rocks are of unknown but great thickness, and are widely scattered throughout the Adirondacks, thus showing that the whole region was under water at the time of their deposition.

After the deposition of the Grenville sediments the region was raised above the ocean level and the rocks began to decompose and suffer erosion. Either just before, during, or after the uplift, great masses of igneous rocks were intruded. The Grenville rocks were for the most part engulfed by the intrusion so that only occasional patches of them were left intact.

After the igneous activity the rocks became thoroughly metamorphosed by being squeezed, highly folded and converted into gneisses. Such changes can take place only at great depths (several thousand feet) and hence we are led to the belief that a vast erosion of the original land masses must have taken place. This in turn signifies that the land masses must have remained above sea level for an immense length of time.

At or toward the close of this long period of erosion, igneous activity of a minor character took place. The basic igneous rocks erupted at this time are especially well shown in the northeastern Adirondacks, where they were squeezed up between joint planes in the older rocks. That these rocks are much younger than the igneous rocks first mentioned is clearly shown by their mode of occurrence and their general lack of metamorphism.

Toward the close of the erosion period the region of the Adirondacks was nearer the sea level and of slighter relief than at present. Then the whole region began to sink slowly, allowing the sea to encroach upon the land until only an island was left or probably even until the whole region was under water. During the subsidence, deposition of Paleozoic sediments went on, one layer above another, the younger deposits overlapping each other and encroaching upon the sinking land surface. Since the subsidence was not entirely uniform on all sides certain local variations in deposition occurred.

The first of the deposits to form upon the sinking floor was the Potsdam (Cambric) sandstone now found exposed nearly everywhere except along the southwest border. After this the sediments changed in character and the limestones of the Beekmantown (Lower Siluric) were laid down. Then followed the deposition of the highly fossiliferous Trenton (Lower Siluric) limestones including the Lowville and the Black River limestones. The fairly clear waters full of animal life then gave way to the muddy waters of the Utica, when the Utica shales (Lower Siluric) were deposited. At this time the Adirondack region was probably all under water. Next came an uplift on the east and northeast where depositions ceased. On the south and southwest, however, deposition continued and the successive formations of the Siluric and Devonic above the Utica shale were laid down. These Paleozoic formations may now be seen as one passes from the Adirondacks southward to the southern border of the State.

The last period of igneous activity in the Adirondacks occurred some time after the close of the Lower Siluric. This activity was of minor extent and showed itself in the form of dikes.

At some time after the deposition of the Utica shale the rocks, especially along the southern border, were deformed chiefly by faulting. A series of these faults extends across the Mohawk valley. The western Adirondacks, including the Port Leyden quadrangle, have been subjected to erosion for a vast length of time, certainly since the close of the Paleozoic and more than likely since the Devonic. During this great lapse of time a large amount of material has been removed. Doubtless the whole Port Leyden quadrangle was at one time covered by the Utica and Lorraine shales, which have all been removed except along the western side.

The superficial deposits, such as the sands and gravels which are so prominent in the Port Leyden district, were formed by, or along the border of, the great ice sheet of the Glacial age. From the geological standpoint this ice sheet was present only quite recently and covered most of New York State.

TOPOGRAPHY AND DRAINAGE

The Black river valley may be looked upon as the principal topographic feature along the western border of the Adirondacks, and the Port Leyden quadrangle represents a considerable portion of this valley where it is deepest. Black river enters the quadrangle at the southeast corner at an elevation of 1000 feet and, after following a northwest-north course, leaves it near the middle of the northern boundary at an elevation of about 740 feet. From the river eastward there is a general upward slope toward the Adirondacks. Facing the river there is a steep slope, which within 2½ miles, passing eastward, gives way to a generally level sand-flat area lying at an elevation of from 1200 to 1300. Along the eastern edge of the map several points reach altitudes of from 1300 to 1340 feet.

Passing westward from the river the general rise is much more rapid. Two terraces are here well developed from the latitude of Port Leyden northward. The lowermost terrace is from 2½ to 4 miles wide and has a steep front rising from 300 to 400 feet just west of the river. The upper terrace is known as Tug hill whose very steep eastern front rises from 400 to 450 feet and makes up the western portion of the quadrangle. The highest point on this side of the river is Gomery hill, near the western edge of the map, which shows an elevation of nearly 2100 feet, while altitudes of 1800 to 1900 feet are common. This high ground to the west of the river is a part of the broad high land area which lies between Black river and Lake Ontario. It is interesting to note that the elevations of the western portion of the quadrangle are much greater than those of the eastern or Adirondack portion. In order to reach elevations of 2100 feet or over it is necessary to pass 20 or 25 miles east of Black river into the Adirondacks to the high points around the Fulton chain of lakes.

Within the map limits Black river descends 200 feet, through a series of still waters and rapids, before reaching Lyons Falls. At Lyons Falls there is a sudden drop of 60 feet, but from this point northward to the map limit the river flows by a winding course through an old lake bottom [*see* p. 54] and the gradient is almost imperceptible. The largest tributaries to Black river from the east are Fall brook, Moose river, Fish creek, Otter creek and Independence river. By far the largest of these is Moose river, one branch of which drains the Fulton chain of lakes. Chief among the tributaries from the west are Sugar river, Mill creek, House creek, Whetstone creek and Roaring brook. All the larger streams which have cut across the steep eastern front of Tug hill have there cut out deep narrow gorges locally called "gulfs." More special physiographic features will be described later.

PRECAMBRIC ROCKS

The Precambric rocks of the quadrangle represent a portion of the great Adirondack crystalline mass along its extreme western border. They occupy the eastern side of the quadrangle and make up a little less than one half its area. Except at the extreme south the Paleozoic-Precambric boundary line is everywhere to the west of Black river, but it keeps close to the river bottom. These crystalline rocks continue westward, under cover of the Paleozoics, for many miles. Considerable portions of the Precambric area are so deeply buried under glacial drift deposits that it is impossible to gain even the slightest clue as to the character of the rocks in those places.

Grenville gneiss

The Grenville formation takes its name from Grenville, Canada. It comprises a series of gneisses representing very ancient sedimentary rocks which have been so profoundly metamorphosed that the original sedimentary features have been largely obliterated. So far as can be definitely proved they are the oldest exposed rocks in the whole Adirondack region. That they are not actually the oldest rocks is evident from the fact that these sediments must have been deposited upon a still older floor. This very ancient rock floor, which may or may not represent a portion of the earth's primitive crust, has thus far not been proved to exist in the present exposures of the Adirondacks. It is barely possible that some of the gneisses still of doubtful age and origin may represent that ancient sea-floor.

Within the map limits the Grenville has been mapped in only three small areas, one at Kosterville, another at Lyonsdale, and a third to the east of Fowlersville. Grenville rocks are unquestionably present in much greater force than these small areas seem to indicate but they are always so thoroughly involved with other gneisses that they can not be represented on the geologic map as such. Occurrences of this kind will be described later.

One of the strongest proofs of the sedimentary origin of the Grenville is the presence of limestone beds in the formation. Such limestones have been described by Smyth[1] in the Diana-Pitcairn area some 30 miles northward and also at the Fulton chain of lakes some 25 miles eastward. A little has been found by Mr D. H. Newland in the Little Falls district and also on Moose river a few miles east of the Port Leyden quadrangle. The latter occurrence is the closest to the Port Leyden quadrangle so far known. The writer has found no actual limestone on either the Remsen or the Port Leyden sheet although certain gneisses usually associated with the limestone are present. The statement may be repeated that, whereas Grenville limestone is common along the northwestern Adirondacks, it is only sparingly represented along the southwestern border.

The fact that commonly the Grenville rocks here and elsewhere are in alternating layers which stand out in sharp contrast because of marked differences in composition and color leads to the belief that these bands are due to differences in original sedimentation. At times the gneiss is composed of almost pure quartz and could scarcely be of igneous origin.

Graphite is a form of crystallized carbon and of organic origin. Its presence as flakes in certain of the Grenville gneisses, including some within this quadrangle, affords a strong argument in favor of the sedimentary origin of those gneisses. Garnet is frequently present, often in great abundance, and it is rather more common in metamorphosed sediments.

Of the three areas above mentioned, each has certain distinctive features and hence they will be separately described. Thus in the Kosterville area the rocks are mostly quartz-sillimanite gneisses in thin layers and weathering to a rusty brown. They are not sharply separated from the neighboring rocks and some feldspar-garnet gneisses appear near the northern border of the area and along the river below Shuetown. The dip of the foliation is northward while the strike is about n. 60° e. which is the same as for the surrounding rocks. The specimens here described were taken from the fine exposures just below the bridge across Moose river. Microscopic study shows one

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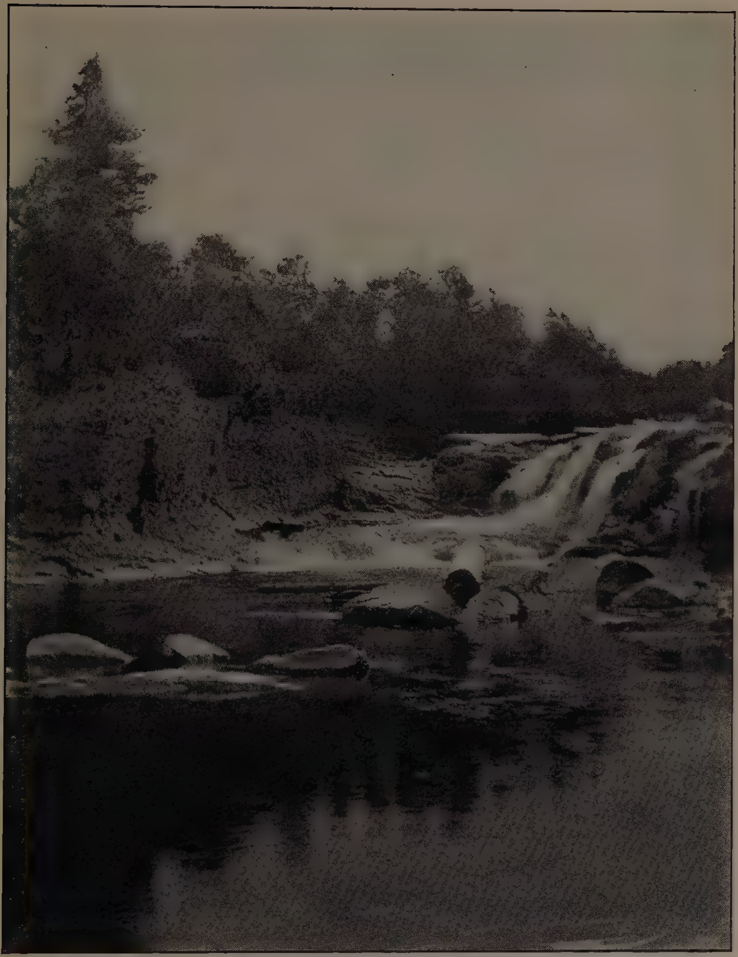
[1] Crystalline Rocks of the Western Adirondack Region. N. Y. State Mus. 51st An. Rep't. 1897. 2:469-97.

Plate 1



W. J. Miller, photo

Grenville gneiss just below the Moose river bridge at Goulds Mill. The rock is here practically a thin bedded quartzite.

specimen to be made up as follows: quartz 75%; sillimanite 12%; and with the long axes of the glistening needles parallel to the rock bands; enstatite 5%; magnetite 3%, and changing to leucoxene; pyrite 2%; garnet 2%, and often completely enveloping the magnetite; together with a little zircon and badly decomposed biotite. Another specimen shows from 85 to 90% of badly cracked quartz; 1 or 2% each of hornblende, pyrite and sillimanite with a little zircon; while the rest of the rock is made up of gray, uncrystallized, yellow-stained, decomposition products of hornblende and biotite. Certain other layers are slightly feldspathic. The most striking features in the composition are the very high quartz content, the almost complete absence of feldspar, and the dearth of dark colored minerals. The rock thus appears to have been an almost pure sandstone which has been metamorphosed to a quartzite. The rock is highly cataclastic and that the mass has been subjected to a great pressure is proved by the local folds and by the general crushed appearance of the exposures [*see* pl. 1]. In the field the rock has a decidedly sedimentary look and we have here a fine example of the Grenville which does not appear to have been very profoundly changed from the original sediment. Where these gneisses grade into the surrounding mixed gneisses some feldspar and a larger percentage of dark colored minerals are present.

The Grenville rocks in the Lyonsdale area are chiefly feldspar-garnet-mica gneisses. The gneissic structure is here greatly accentuated by the alternation of light and very dark gray layers which are usually from a few inches to a foot or more in thickness. A thin section of the light gneiss shows quartz 75%; feldspar 15 to 18%, mostly oligoclase to labradorite, but with a little microperthite; biotite 5%, and garnet 2 or 3%. In the dark gneisses the quartz is proportionately less prominent while the biotite may run as high as 35 or 40%. Both the light and dark rocks are often very garnetiferous. In some specimens a few small flakes of graphite were noted. The original sediments here were probably somewhat carbonaceous shales and shaly sandstones.

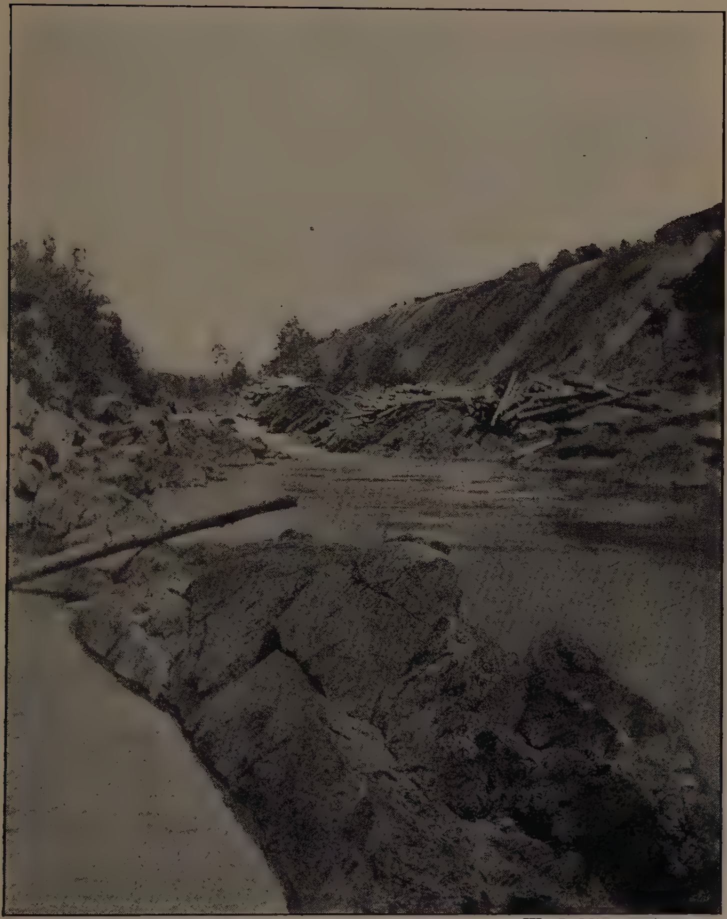
The rock bands show a northward dip at a high angle and a strike of n. 40° e. On the north side the exposures are not good but the Grenville does not seem to be sharply separated from the surrounding rocks, while on the south side, along Moose river, there is exhibited a very sharp contact between the Grenville and the syenite. The more resistant syenite here forms a high, steep rock-wall on the south side of the river, while the less resistant Grenville gneisses have been deeply trenched by the river [*see* pl. 2]. Moose river really bears about n. 40° e. here and parallel to the foliation instead of nearly east and west as shown on the map.

In the area east of Fowlersville the Grenville rocks are chiefly pyroxene gneisses. The gneissic structure is highly developed and accentuated by the alternations of light and dark colored bands although none of the rocks are very dark colored. The bands are seldom more than a few inches thick. Microscopic investigation shows the common rock to be made up as follows: 40 to 50% of quartz; 25 to 30% of large, bright green, pyroxene crystals, sometimes slightly pleochroic; about 25% of feldspar, mostly orthoclase together with a little acid plagioclase; 3 to 5% each of hypersthene and enstatite; and a little bronzite and white pyroxene. Judging by the composition the sediments from which these rocks were derived were probably shales or shaly sandstones possibly somewhat calcareous. These gneisses are very similar to those referred to by Smyth as being directly associated with limestone. Although no limestone is here seen in outcrop, it is possible that some does occur along the east side of the area which may thus account for the distinct depression (now drift-filled) along that side and from which some softer or less resistant material has certainly been removed by erosion. Associated with these gneisses are a few layers rich in basic plagioclase feldspar and poor in pyroxenes and which have the appearance of igneous rocks. This Grenville area forms a long, narrow ridge which stands out as a distinct topographic feature. Moose river has cut a channel across this ridge. The rocks dip at an angle of 40° or 50° westward and strike almost due north and south. Outcrops of syenite have been found on all sides of, and pretty close to the Grenville mass. There are no sharp contacts visible but it seems certain that we are here dealing with a long, narrow inclusion of the Grenville in the syenite. This matter will be further discussed below under the heading " Syenite gneiss."

Syenite gneiss

As indicated on the geologic map, syenite gneiss makes up a considerable portion of the known Precambric area. From the standpoint of both composition and structure it is very uniform

Plate 2



W. J. Miller, photo

Moose river gorge just east of Lyonsdale. The rocks in the bed of the river are garnetiferous gneisses belonging to the Grenville. The high, steep rock on the right side is syenite which is in sharp contact with the Grenville.

over pretty large areas and it is clearly the most homogeneous rock mass among the Precambrics. The typical rock is a quartz-hornblende syenite always showing the granitoid texture. The quartz content varies a good deal but apparently without otherwise affecting the rock. The dark colored minerals are always very subordinate in amount. On weathered surfaces the color of the rock varies from a light brown to a reddish brown, while the color of the fresh rock varies from a sort of greenish gray to a light gray. The rock is nearly always medium grained although somewhat variable in this respect. In the field the rock always clearly exhibits a gneissic structure which usually can not be made out in the hand specimen. A distinct banding is seldom shown except at times near the borders where the syenite grades into the surrounding rocks. The minerals are roughly arranged with their long axes parallel to the strike of the foliation which ranges from n. 30° to 70° e. Such an arrangement of the dark colored minerals causes the foliation to be more evident, but they appear like wavy streaks which are seldom continuous for more than a few inches or a foot. The homogeneity of this syenite and its lack of distinct banding serve to separate it from the other Precambric rocks in the field.

The only noteworthy departure from homogeneity is to be found in the presence of occasional small dark basic patches in the syenite. These patches nearly always show abrupt terminations and to all appearances they are true inclusions. They are rich in hornblende and biotite and are invariably arranged with their long axes parallel to the gneissic bands of the syenite. Such inclusions may be seen in the field southeast of Denley; near where Miller brook enters the quadrangle; and probably best in the large exposures southwest of Partridgeville. Most of the syenite outcrops are, however, entirely free from such inclusions.

A number of syenite areas are shown on the accompanying geologic map. Of these the southernmost one extends from Denley southeastward to Hawkinsville and represents probably the purest and most typical syenite of the region. Fine exposures occur in the fields southeast of Denley and in the vicinity of Hawkinsville. A large area extends from Miller brook northward to Moose river with good outcrops along Fall and Miller brooks; at Fowlersville and for 2 miles southward; and just east of Lyonsdale. Another large area occupies the northeastern portion of the quadrangle with fine exposures between Brantingham lake and Partridgeville and also where the road leaves the map east of Brantingham post office. The area between Greig and Donnattsburg shows many large outcrops of rock which here as well as around Partridgeville are more quartzose than usual. Smaller patches of rather quartzose syenite are shown at Lyons Falls and in the river bottom east of Glenfield.

The rock exposed in the quarry southeast of Denley may be taken as typical of the best syenite of the quadrangle and a detailed description of this type will now be given. In thin section fresh feldspar is seen to be the most common mineral which makes up 75 to 80% of the rock. Much of the feldspar is present as microperthite usually in large crystals and with the microperthitic structure beautifully exhibited. There is also a considerable percentage of another feldspar, presumably anorthoclase, which is characterized by a sort of moire or clouded appearance. There is a small amount of plagioclase feldspar ranging from oligoclase to andesin. The second most common mineral is quartz of which there is 12 or 15%. The quartz grains are very variable in shape and size and are frequently broken as a result of pressure. Of the dark colored minerals hornblende and biotite make up about 5% of the rock. The hornblende is the common green variety with usual pleochroism and shows frequent alterations to chlorite. 1 or 2% of magnetite, sometimes with leucoxene borders, is also present. Beside these a few small crystals of zircon, apatite, and zoisite may be seen nearly always as inclusions.

A study of the thin sections from the different syenite localities shows a range of minerals as follows: Feldspar 60 to 80% — microperthite always abundant, anorthoclase none to 20%, oligoclase none to 10%; quartz 15 to 30%; hornblende none to 5%; biotite none to 3%; magnetite none to 3%, and zircon, apatite and zoisite are nearly always present in very small amounts. In one or two cases a little garnet has been noted. The cataclastic structure is always more or less well developed in the syenite, sometimes being very prominent, which shows that the rock must have been subjected to a pretty severe dynamic metamorphism.

In Cushing's[1] typical syenite at Loon lake and Smyth's[2] typical rock in the Diana-Pitcairn area, the dark minerals, especially pyroxene, are prominent constituents, while in the Port Leyden district the pyroxene is always absent and the dark minerals never amount to more than 7 or 8%. Otherwise the rocks are very similar. In passing northwestward from Little Falls to Port Leyden the syenite loses its pyroxene and the microperthite becomes more prominent than the anorthoclase.

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[1] Geol. Soc. Am. Bul. 1899. 10:177-92.

[2] *loc. cit.* p. 473.

It is now well established, especially by the excellent work of Smyth,[1] that the syenite is a plutonic igneous rock which has been intruded into and is therefore younger than the Grenville. The evidences from the Port Leyden region are clearly in harmony with this view. Thus the Grenville area east of Fowlersville is surrounded by pure syenite and the writer is convinced that we have here a good example of a large Grenville inclusion in the syenite. Significant in this connection is the fact that the strike of the foliation in the Grenville is north and south while that of the nearby syenite is about n. 30° e. This would be expected especially where large sedimentary masses were caught up in the molten syenite. Near Lyonsdale, on the south side of the river, the syenite and Grenville are in sharp contact while north of the river they appear to blend into each other. Around Kosterville no sharp contacts are seen but the syenite and Grenville seem to be mixed around the borders of the Grenville. Referring to similar phenomena farther northward Smyth[2] says: " Some of these inclusions are clearly defined with sharp boundaries but others are somewhat blended with the surrounding syenite as though they had undergone a partial melting." The small basic inclusions above mentioned and the very intimate mixture of syenite and Grenville on a large scale as described below also argue for the intrusive character of the syenite.

Granitic syenite gneiss

In the northern portion of the quadrangle, and on either side of Black river, two areas of granitic syenite gneiss are shown on the geologic map. These areas are probably continuous under the broad drift-filled valley bottom. This rock is almost certainly a granitic phase of the normal syenite above described, and, since the one rock grades into the other, the drawing of a boundary line must of necessity be an arbitrary matter. In order to distinguish the granitic syenite from the normal syenite several features, given in the following description, must be considered.

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[1] *loc. cit.*

[2] *loc. cit.* p. 477.

The rock is not only clearly gneissoid but also distinctly banded. The rock bands are straight and rather persistent and the minerals are commonly arranged with their long axes parallel to the foliation. Frequently the "leaf gneiss" effect is beautifully shown because of the flattening out of the quartz and feldspar crystals. The color of the typical rock is red although at times gray bands are present. The size of the grain is rather variable but mostly pretty coarse. At times the quartz and feldspar crystals are almost porphyritic. The average quartz content is noticeably higher than in the normal syenite and commonly the more weathered surfaces show numerous projecting quartz crystals; often the rock might well be called granite. The granitic syenite also lacks the homogeneity of the ordinary syenite. In the larger exposures of the typical red quartzose gneisses there are occasional bands of gray, less quartzose gneisses very similar to the normal syenite.

Another noteworthy feature is the presence of long, narrow patches or inclusions much like those sparingly present in the ordinary syenite, but they are here much larger and more numerous. They are always drawn out perfectly parallel to the foliation planes but they are seldom more than 30 or 40 feet in length. They are composed of about equal parts of badly decomposed basic plagioclase and brown hornblende with which are associated thin layers of almost pure biotite. These biotite layers often give the rock a decidedly schistose appearance. The presence of these basic patches has doubtless aided in the production of the distinct banding of the granitic gneiss during the process of dynamic metamorphism. In this connection the writer has read the recent paper[1] by Professor Adams which deals with the origin of the amphibolites in the Glamorgan granite of Ontario, Canada. He says: "Here the limestone (Grenville), toward the granitic contact, passes gradually over into amphibolite, the latter being undoubtedly produced by the alteration of the former. . . The granite, furthermore, not only penetrates the (limestone) series, but floats off masses of the altered rock which in the form of bands, streaks, and isolated shreds are seen thickly scattered through the granite in the vicinity of the contact and which while less abundant, are found throughout practically the whole extent of the bathylith." Judging from his descriptions of the amphibolites, the inclusions in the Port Leyden region are very similar to them and, although we have here no such positive evidence for their origin, the explanation above given by Professor Adams becomes very suggestive at least.

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[1] Jour. Geol. 1909. 17:8.

In a general way at least, another distinction from the syenite is the more complete granulation of the granitic gneisses. Under the microscope the cataclastic structure is always well exhibited, sometimes to a remarkable degree. The quartzes were most badly broken by the grinding action and strain shadows are common.

In thin section the typical red granitic syenite from near the lower road crossing on Otter creek is seen to consist of about 60% of feldspar; 35% of quartz; 3% of hornblende; 2% of magnetite, and a very little zircon and apatite. The feldspar is chiefly microperthite accompanied by some anorthoclase and a little oligoclase. Red hematite stains are common in the sections. Closely associated with this typical rock, but always in subordinate amount, is a gray, less quartzose and more truly syenitic rock. In all of the sections of the granitic syenite examined the feldspar ranges from 60 to 70%. Microperthite is the chief feldspar, while anorthoclase ranges from absence to 20%, and oligoclase never exceeds 5%. The quartz range is from 25 to 40%. Hornblende is always present but never above 5%. Biotite is often absent and never exceeds 2%. From 1 to 4% of magnetite always occurs. Small crystals of apatite and zircon are common.

It seems certain that this red granitic gneiss is a differentiation phase of the normal syenite gneiss. Except for the greater granulation and somewhat higher quartz content, microscopic study shows no difference between the rocks. In the field no sharp line of separation can be drawn. The normal syenite in general seems to become more quartzose toward the north so that in this respect, at least, the syenite around Partridgeville closely approaches the granitic syenite. The writer is inclined to the belief that the passage from one rock to the other is much like that described by Smyth in the Diana area some 20 or 25 miles northward. He says:[1] "Passing southward from the latter (limestone formation) the syenite at first slowly and irregularly then more rapidly increases in gneissoid structure till at a distance of from 3 to 5 miles from the limestone a region of red hornblende gneiss is reached. . . West of Natural Bridge in Jefferson county the syenite unquestionably passes over into a very perfect red gneiss. . . Both in the field and under the microscope the gradual change of the rock can be followed through every step." The same sort of a change has been observed by Cushing in the Tupper Lake syenite.[1]

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[1] *loc. cit.* p. 481–82.

Syenite-Grenville mixed gneisses

A considerable portion of the known Precambric rock area has been represented upon the geologic map as being made up of various mixed gneisses. These gneisses include a great many rock varieties which make up a heterogeneous mass. After a careful study of these gneisses the writer is fully convinced that, for most part at least, they represent a more or less intricate mixture of the syenite and Grenville rocks. Some of these gneisses are admittedly of uncertain origin. Certain small patches within these areas are undoubtedly rather pure Grenville, while others seem to be pure syenite, but the small scale of the map does not permit these to be separately shown. Sometimes the syenitic and sometimes the Grenville facies predominate. These rocks are everywhere thoroughly gneissoid and they are generally well banded except in some of the more syenitic masses. The " leaf gneiss " structure is at times well developed.

It has already been stated that the syenite is intrusive into and younger than the Grenville and that the Grenville areas must be regarded as large inclusions. A study of the syenite-Grenville mixed gneisses furnishes convincing evidence of the same kind. Actual inclusions of undoubted Grenville may occasionally be seen within the syenitic masses. Such inclusions may be seen in the vicinity of Lyons Falls; ½ mile north and 1 mile east of Port Leyden; 1½ miles above the mouth of Miller brook; 1 mile above the mouth of Fall brook, etc. As already suggested, the writer is of the opinion that the Grenville was often either partially or wholly incorporated into the syenite by fusion when the latter came up in a molten condition. Various rock types formed in this way would depend partly upon the degree of metamorphism and partly upon the character of the Grenville. The masses of rather syenitic looking rocks which

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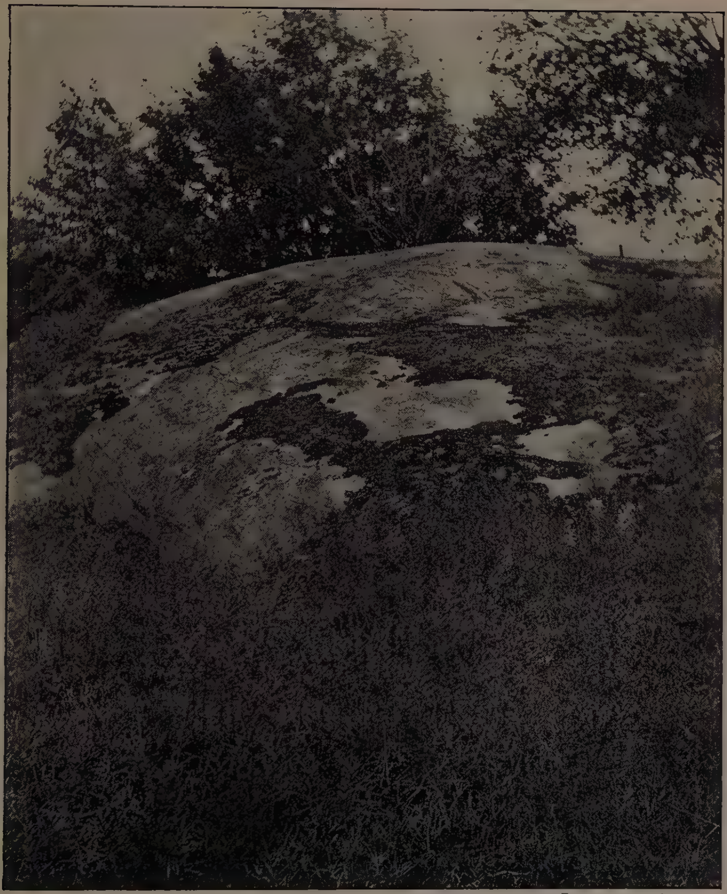
[1] N. Y. State Mus. Bul. 95, p.323.

Plate 3



W. J. Miller, photo

A typical Precambric exposure ½ mile north of Lyons Falls station showing the smoothed, glaciated character of the surface. The rock is a syenitic facies of the syenite-Grenville mixed gneisses.

are quartzose and garnetiferous may be accounted for by some such process.

Three syenite-Grenville areas are shown on the map. The largest of these extends from Denley station to north of Greig, a distance of nearly 12 miles, while the width averages something like 3 miles. In the southern portion of this area the Grenville is present in greater force than the syenitic or granitic rocks, while in the northern the reverse is true except possibly in the vicinity of Greig. Within this area there seems to be good evidence for the former existence of very ancient Grenville rock belts or structure lines which extended in a northeast-southwest direction. Thus pyroxene gneisses are found in the area east of Fowlersville; in small outcrops 1½ miles east of Port Leyden; and 1½ miles north of Denley, and these are all arranged along a northeast-southwest line. A belt of feldspar-garnet gneisses shows a similar strike and extends from Lyonsdale to Port Leyden. Quartz-sillimanite rocks much like those at Kosterville have been noted in small exposures from ½ to ¾ of a mile north of Port Leyden and this suggests another northeast-southwest belt. A less well defined belt is garnetiferous and passes through Lyons Falls. Still another belt, in which garnet-sillimanite gneisses are commonly found, passes northeast and southwest through Greig. It seems pretty certain that before the intrusion of the syenite, these Grenville belts were continuous and well defined and that as a result of the intrusion they were all cut up leaving only here and there masses of the pure Grenville.

Of the two smaller syenite-Grenville areas, one lies about 2 miles north of Fowlersville and the other around East Martinsburg. These rocks are quartzose syenites often containing garnets and more or less intermingled with Grenville.

The great variety of rock types making up this complex and their gradations from one type to another make it difficult to give a proper idea of them by description. Microscopic study of numerous thin sections shows the presence of all the minerals of both the Grenville and the syenite and in addition to them microcline which often occurs as a prominent feldspar. The following brief descriptions include most of the leading types:

1 Syenitic facies. These are often practically indistinguishable from the normal syenite. They are usually, however, pretty fine grained and under the microscope nearly always show a highly cataclastic structure. They frequently contain microcline

feldspar and a large proportion of quartz and the dark colored minerals. Thus a specimen from along the railroad 2½ miles north of Lyons Falls contains 75% of microperthite; 20% of quartz; 5% of magnetite, biotite and hornblende, together with a little zircon. Another from ⅔ of a mile southwest of Goulds Mill contains 65%, in about equal amounts, of microcline, microperthite and plagioclase (oligoclase to labradorite); 25% of quartz; and 10% of biotite and magnetite. North of Lyons Falls, along the railroad, similar rocks often carry 30 to 40% of quartz with sometimes a little anorthoclase and they greatly resemble the granitic syenite.

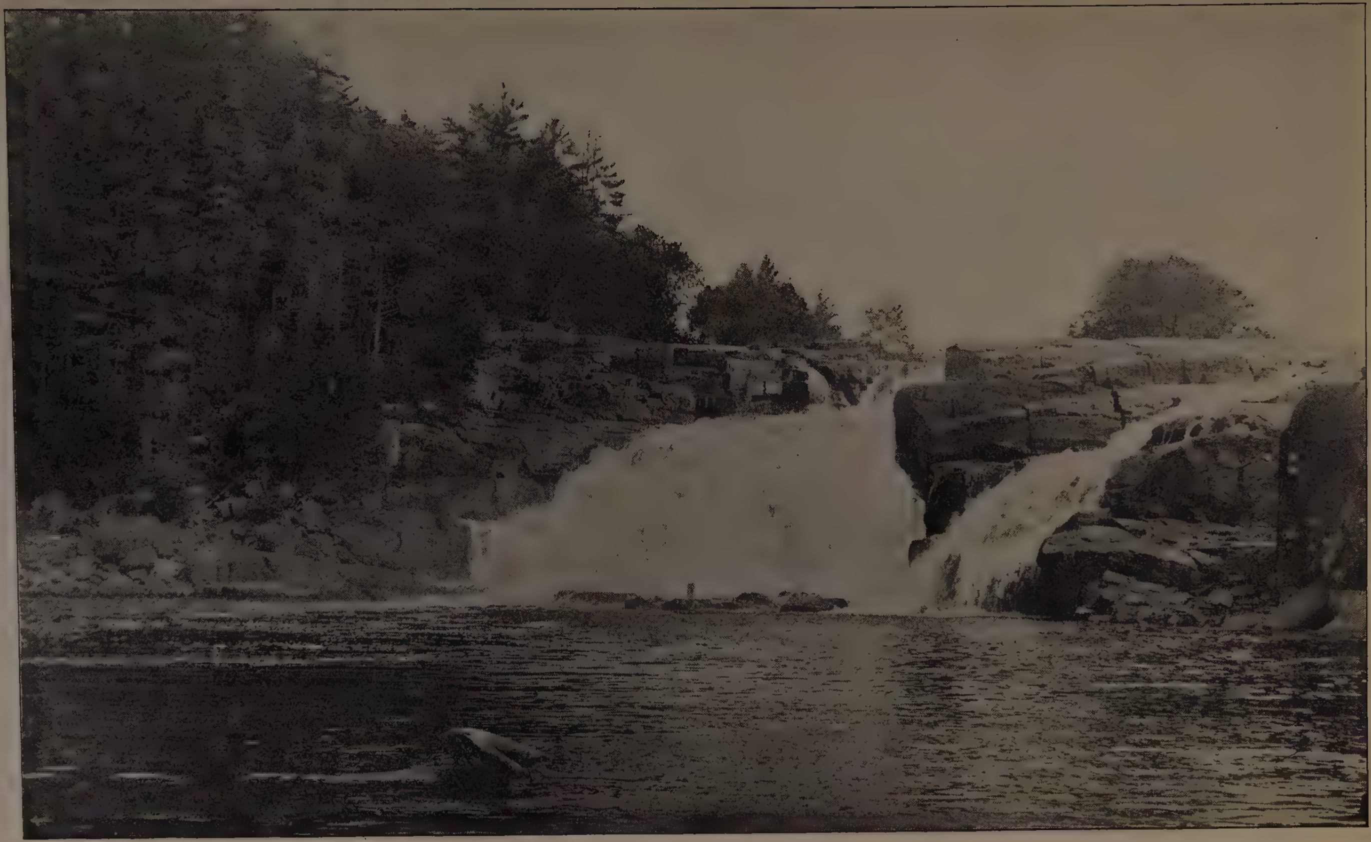
2 Grenville facies. Small exposures often show very pure Grenville as for example at the river dam ½ mile north of Port Leyden. A thin section from here shows 80% quartz; 10% sillimanite; 8% magnetite and 2% biotite, together with a little zircon. Again, a typical pyroxene, quartz gneiss is associated with syenitic rocks 1½ miles above the mouth of Miller brook. A Grenville facies carrying garnets occurs in the vicinity of the paper mill at Lyons Falls.

3 Garnetiferous gneisses with a general igneous appearance are very common. Such a rock 2 miles east of Port Leyden shows 65% of microcline and microperthite; 20% of quartz; 5% of hornblende and biotite and 10% of augite, magnetite, garnet and zircon. A similar type much richer in garnet and almost free from dark minerals occurs in the river bed at Port Leyden. Another type from 2½ miles east-southeast of Greig shows 65% of plagioclase (oligoclase to labradorite); 30% of quartz and 5% of biotite, garnet, magnetite and zircon. The origin of these gneisses is doubtful but they may have been formed by a thorough mixing of Grenville masses with the molten syenite. The garnets in these rocks are frequently an inch or more across.

4 A very gneissoid, rather dark rock, which is fairly common, is rich in plagioclase, quartz and biotite. An example from ½ mile south of Lyons Falls contains 45% of plagioclase (oligoclase to andesin); 40% of quartz; 10% of biotite; 2% of hornblende and 3% of magnetite, zircon and pyrite.

5 A very gneissoid, dark rock from 1½ miles east of Port Leyden contains 50% of microcline and plagioclase (oligoclase to labradorite); 20% of quartz and 10% each of green augite, biotite, magnetite and a very little garnet.

6 A type of dark, quartzless, gabbroic rock such as that at Lyons Falls dam contains 55% of plagioclase (oligoclase to labrador-



Falls of Black river at Lyons Falls. The rock here is a dark, gabbroic mass which has been mapped with the syenite-Grenville mixed gneisses.

ite); 40% of green hornblende and green augite and 5% of hypersthene, magnetite, biotite, zircon and apatite. This type is in contact with another gabbroic rock which has a considerable percentage of quartz and hypersthene and some microperthite.

7 Very dark, long, narrow patches which are probably inclusions are common. They usually consist mostly of decomposed hornblende and basic plagioclase together with some quartz, magnetite and biotite.

Undetermined Precambric areas

Unfortunately several large Precambric areas are so deeply buried under Pleistocene deposits that the character of the underlying rocks is entirely unknown. These areas have been so indicated upon the geologic map.

PALEOZOIC ROCKS

The Paleozoic rocks occupy a little over one half the area of the quadrangle on the west side. Except at the extreme south they always lie to the west of Black river. The maximum thickness of the Paleozoic formations is approximately 1500 feet.

Potsdam sandstone

The Potsdam sandstone is of upper Cambric age and is the most ancient sedimentary formation bordering the Adirondacks. It is not present in outcrop in the Port Leyden quadrangle nor in fact along the whole southwestern border of the Adirondacks, although it is most likely present beneath the later formations. South of Port Leyden the deep wells at Utica and at Rome show a basal sandstone which is more than likely the Potsdam. West of Port Leyden the Potsdam, according to Orton,[1] is most certainly present in the deep wells of Oswego county at Central Square, Parish, Pulaski and Stillwater. The nearest outcrops of the sandstone are something like 20 miles north-northwest of the Port Leyden quadrangle and from there northward to the St Lawrence it is a common surface rock.

Pamelia limestone

The Pamelia limestone was named by Professor Cushing from a town in Jefferson county where he recently recognized it as a distinct formation.[2] Between the Potsdam and the Pamelia, in the St Lawrence and Champlain valleys, other formations come in whose exact relationships have not yet been made out. According to Ulrich the Pamelia is to be correlated with a part of the Chazy of the Champlain valley. For a long time the Pamelia had been described and mapped as Beekmantown limestone, but it now seems to be pretty well established that the true Beekmantown is not present along the northwestern Adirondacks.

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[1] Petroleum and Natural Gas in New York. N. Y. State Mus. Bul. 30. 1899.

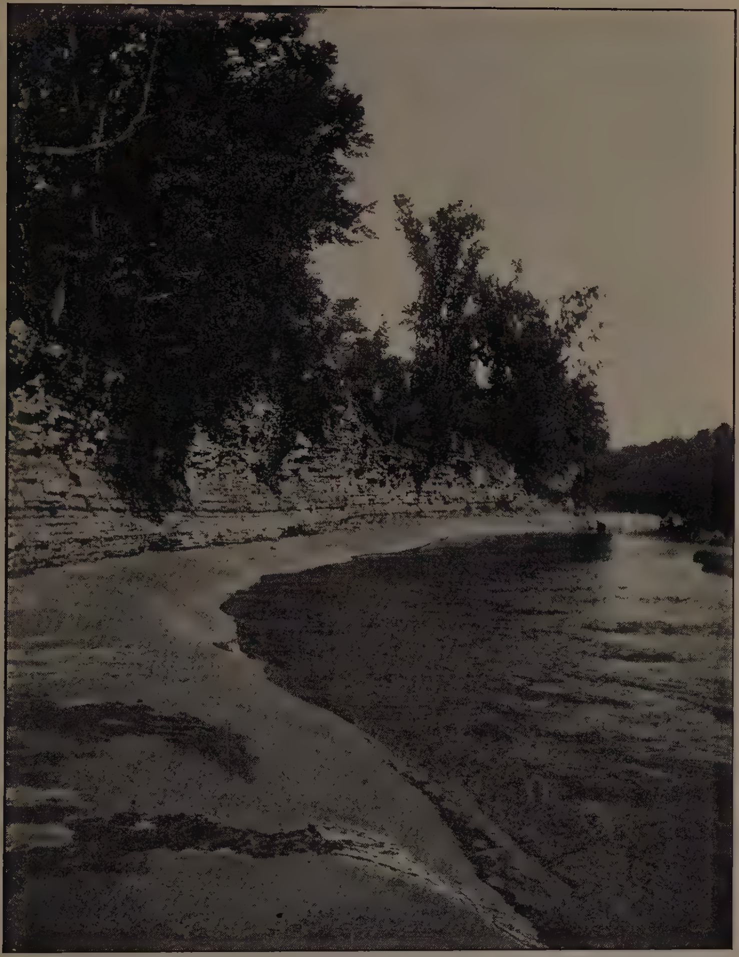
Geol. Soc. Am. Bul. 1908. 19:155-76.

The Pamelia formation (Lower Siluric) is the oldest sedimentary mass exposed within the limits of the quadrangle. Its outcropping edge, which extends from north to south across the district, everywhere rests directly upon the Precambric rocks. Since it outcrops at the base of the steep slope facing Black river its surface exposure is small. The actual contact with the Precambric may be seen in at least three places as follows: Where the railroad crosses Roaring brook near Martinsburg station; along the creek 1⅓ miles northwest-north of Lyons Falls; and along the railroad ¾ of a mile north of Port Leyden. At a number of other places the contact is almost visible. The bed in actual contact with the Precambric is always a sandy conglomerate above which occur several feet of calcareous sandstones, then a few feet of bluish black, fossiliferous limestone, and finally thin to thick bedded, whitish gray to bluish gray, rather impure limestones which latter make up more than half the section. Many of the upper, gray beds are really magnesian limestones which may be burned for waterlime as has been done at Lowville. The conglomerate and sandstone at the base of the Pamelia represent the materials derived from the Precambric land surface as the sea encroached upon it. According to the observations of Professor Cushing on the Theresa quadrangle, (northward), which are corroborated by the writer on the Port Leyden quadrangle, the basal conglomerate and sandstone represents a shifting upward horizon, due to overlap, as the sea encroached upon the land from west to east. These basal beds are more than likely to be correlated with the Rideau sandstone as described by Ami in Ontario, Canada.

Following is a detailed section made by Professor Cushing along Roaring brook (near Martinsburg station) and kindly furnished to the writer:

	Feet	Inches
4 inches of blue gray calcareous shale above and 9 inches of same beneath with a 4-inch layer of mottled blue limestone like that beneath..	1	5

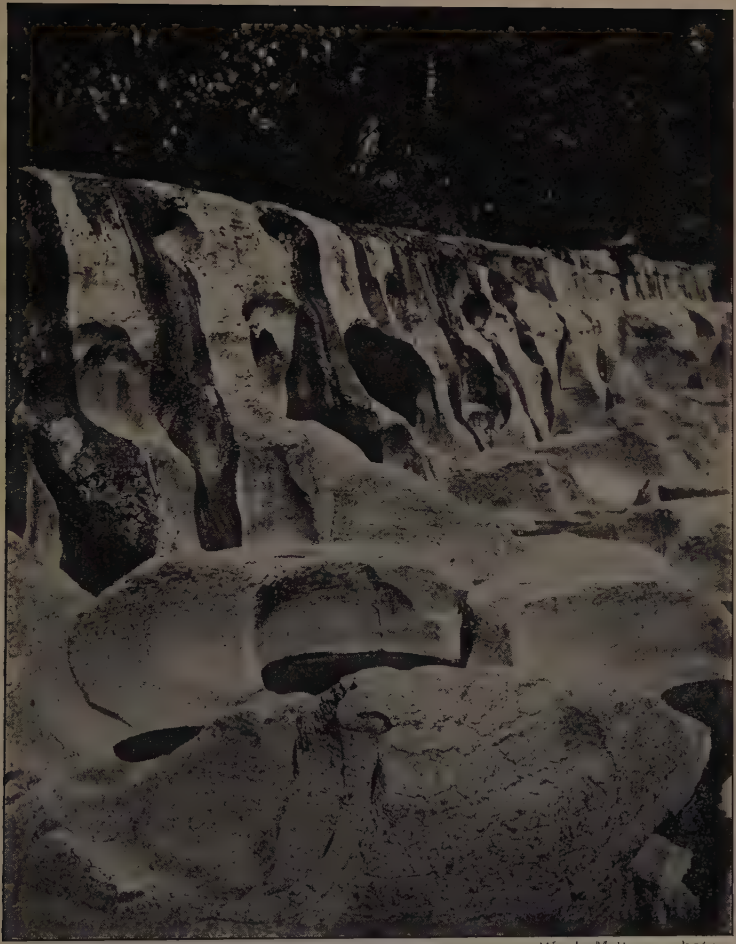
Plate 5



W. J. Miller, photo

View along Black river, 1¼ miles above the mouth of Sugar river, taken to show the sharp contact between the Trenton and the Black River limestones. During high water the thin bedded Trenton limestones have been worn back to leave exposed a distinct platform of the underlying massive Black River limestone.

Plate 6



W. J. Miller, photo

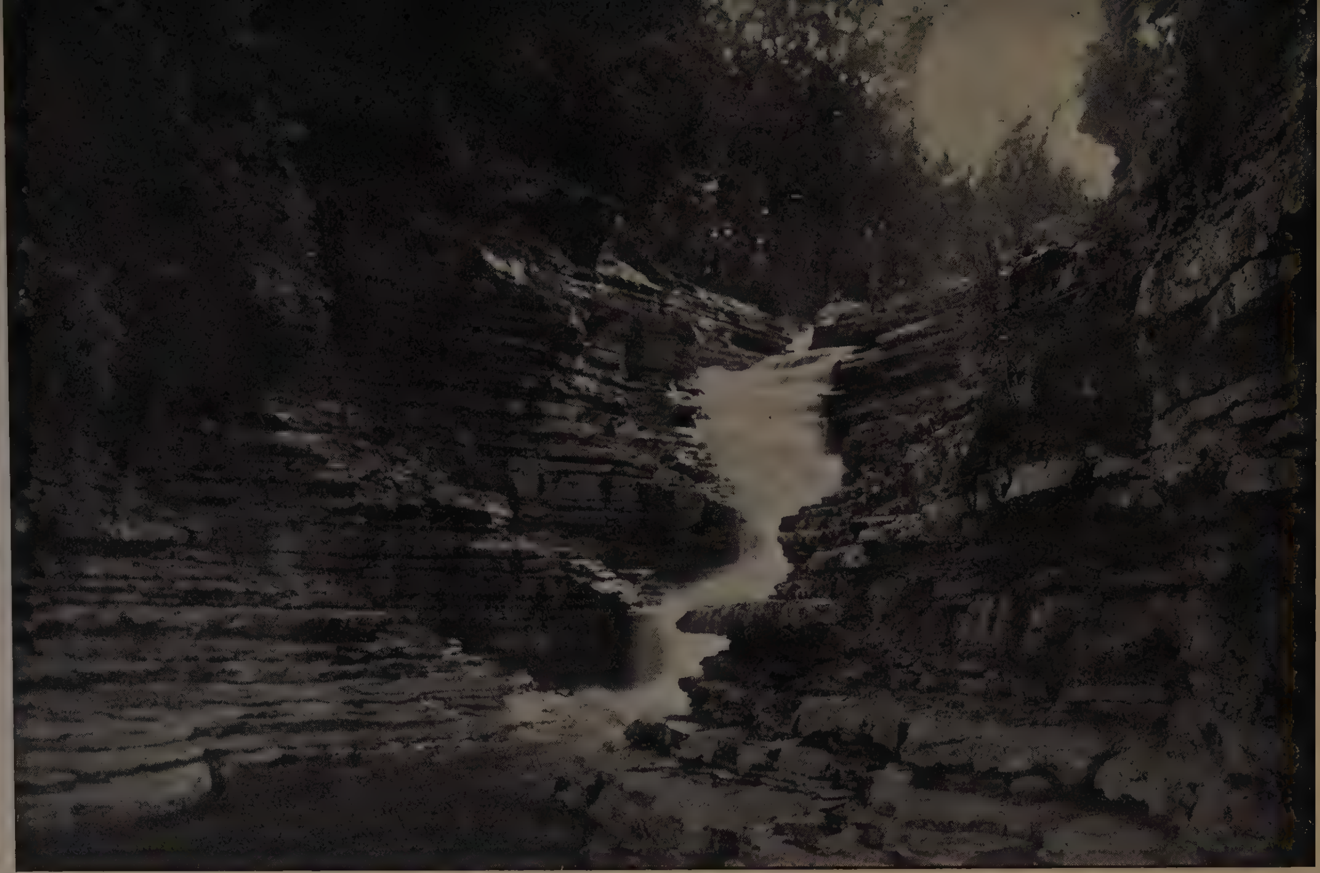
A group of "potholes" in the bed of Sugar river ½ mile below the railroad crossing. The rock is Black River limestone.

	Feet	Inches
A massive bed of blue granular limestone, mottled and laminated and with pebbles of blue dove limestone	1	6
Hard, gray white limestone with spots of crystallized calcite	....	9
Bluish gray, thin bedded limestone, with ripple marks and ostracods	2	2
Shaly, dirty white mud limestone beds, mud cracked	1	6
Bluish subgranular, thin bedded limestone	....	9
Blue dove, hard, mottled limestone, shaly below, traces of fossils	1	4
Hard, gray granular limestone, pinkish tinge, much calcite	....	6
Thin, ripple marked, dirty white, mud limestone beds	1	......
Hard, blue gray subgranular limestone, sand grains and ostracods above	2	6
Hard, gray white limestone, less earthy than usual; calcite spots	....	9
Subgranular, blue, laminated limestone; welded contact with above	2	5
Very massive, gray white, earthy limestone, irregular splitting.	5	9
Massive blue dove limestone in two layers; laminated; styliolites and traces of fossils	1	9
Thin and thick bedded, blue subgranular limestone; massive basal layer; laminated; much mud cracked	7	9
Earthy, impure, gray white beds; massive and irregular splitting; lower 12–18 inches hard, gray white, calcite spotted, bunchy surfaced	3	11
Gray white, impure, earthy, blocky beds	1	8
Impure, gray white, reddish tinged, earthy limestone, with purer layer of reddish limestone at base; quite massive; summit less red	7	8
Bluish black, fine, hard limestone, like 2d beneath but unfossil.	1	......
Gray to blue gray, magnesian looking limestone in 3–6-inch beds	2	9
3 heavy layers of hard, bluish black limestone; ringing; multitude of small fossils, lamellibranchs, cephalopods, one-celled Tetradium, etc.	4	7
Red and green, impure, calcareous, sandy mudstone, large sand grains; upper 6 inches thin bedded, rest massive	7	......
Very sandy firm green limestone, full of quartz grains	1	3
Hard, gray white, somewhat sandy limestone or dolomite; calcite spots	1	2
Hard, ringing, green, calcareous sandstone	....	10
Red, sandy, rotten shale	1	6
More solid, red and green calcareous sandstone; rots easily	4	......
Red and green, rotten, calcareous sandstone	....	9
Green and red arkose; perhaps calcareous	....	11
Conglomerate resting on Precambric	....	10
Total	71	8

Eight miles south of the above section and 1¼ miles northwest-north of Lyons Falls station another excellent section is shown along Mill creek where all the beds from the Precambric to the Trenton are exposed. Mill creek is not properly placed on the map here. Its true course is close to the town line between Turin and West Turin. By means of the hand level the writer has determined the thickness of the Pamelia here to be about 56 feet. The basal conglomerate, 1 foot thick, is followed by 10 feet of gray, calcareous sandstones and very sandy limestones with some sandy shale partings. Next come 4½ feet of bluish black limestones. Above this the beds are much like those along Roaring brook and their summit is here also capped by a limestone conglomerate.

Some 7 miles south of the Mill creek section and in the vicinity of Denley there are good exposures of the Pamelia. No complete section is visible but a study of all the outcrops makes it certain that the formation is here not over 20 feet thick. The basal conglomerate and sandstone underlies grayish, sandy, thick bedded limestones, while the whole is capped by the usual limestone conglomerate. The most southerly outcrops of Pamelia occur along Mile creek from ½ to 1 mile above its mouth, where the formation is apparently not over 10 or 12 feet thick. It disappears before the Remsen quadrangle is reached.

The thinning out to disappearance of the Pamelia in passing southeasterly may be entirely explained as due to overlap, since the formation came in from the west, as above shown, and rapidly thins out eastward. Its place of disappearance, most likely in the northeastern corner of the Boonville quadrangle, is some 9 or 10 miles east of a north-south line passing through the Roaring brook section where the Pamelia is over 71 feet thick. This represents an eastward thinning of 7 or 8 feet per mile which compares favorably with the rate of thinning noted by Cushing over the Theresa quadrangle. Of course, some of the thinning may quite possibly be due to a lack of deposition of so much material in the southern portion of the basin. It seems certain that the Pamelia is present in considerable force, under cover of later rocks, in the western part of the Port Leyden quadrangle and to some extent, at least, in the northern part of the Boonville quadrangle. In a letter Cushing says that what has heretofore been referred to as Beekmantown-Lowville passage beds in the region around Little Falls may in reality be a touch of the Pamelia there.



Falls of Sugar river just above the railroad bridge. The rock is rather heavy bedded crystalline Trenton limestone.

Lowville limestone

The Lowville limestone formation takes its name from the type locality at Lowville a few miles beyond the map limits to the northward. It was formerly called the Birdseye limestone because of the spotted character of the surfaces due to the emergence of the calcite-filled tubes so characteristic of the formation. These calcite-filled tubes stand perpendicular to the stratification planes and were first thought to have been caused by a seaweed of the Fucoid type, but they are now referred to the genus Tetradium of the branching corals. Not all of the Lowville beds contain the Tetradium.

In the old State report by Vanuxem everything below the Trenton, in this region, was described under the heading " Black River limestone," but the following quotation shows that, on lithologic grounds, he recognized three divisions of the formation: " The cliff shows several distinct kinds of limestone, not being a homogeneous mass. The upper part is mixed irregularly with black shale. . . The second division is of a lighter color, with less shale or impurities, more brittle, and contains the Fucoides demissus (Tetradium), etc. . . The third division, and which therefore forms the base of the cliff . . . is light colored, and the surface of some of the layers present mud cracks, showing the presence of shale. It is in these layers that the stone exists which is burnt for waterlime at Lowville."[1] His upper division corresponds to our Black River limestone, the middle one nearly to our Lowville, and the lower one nearly to our Pamelia.

Within the map limits the Lowville, together with the Pamelia, is present, except at the extreme south, as an almost continuous surface exposure or ledge facing the railroad. In spite of its considerable thickness its areal extent is small because of its outcrop along this steep slope. The Lowville beds are mostly bluish dove-colored, pure limestones in beds varying from a few inches to 2 feet thick. Some of the beds are mud cracked, others are shaly, while still others are fossiliferous commonly with the Tetradium. A notable feature is the presence of limestone conglomerate at several horizons. In passing downward this conglomerate is prominent where the pure dove limestones give way to the more impure bluish gray to whitish gray limestones and it is here where the line between the Lowville and Pamelia has been drawn. Within the quadrangle this line is a difficult one to draw with any great degree of accuracy.

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[1] Geol. N. Y. 3d Dist. 1842. p. 42.

According to the work of Cushing and Ulrich farther northward, there is an unconformity separating the two formations, the time gap being represented by the upper portion of the Chazy of the Champlain valley. In the Port Leyden district, the change from the conglomeratic bluish dove limestones to the more impure whitish, sandy beds seems significant and may be due to an unconformity at this horizon. Certainly, however, the writer has found no evidence of any well defined or large unconformity between the Lowville and Pamelia.

In the Roaring brook section as measured by Cushing the Lowville is made up as follows:

	Feet	Inches
6-foot layer of Black River limestone; upper 3 feet full of chert	....	......
Mostly thin bedded blue dove limestone in 6-inch to 1-foot layers, full of Tetradium and other fossils, to base of Black River	7	8
Massive beds of blue dove limestone in 18-inch to 2-foot layers; only sparingly fossiliferous, but more or less Tetradium everywhere	17	4
Shaly, blue dove limestone	1	8
Blue, granular limestone full of fossils and much crystallized calcite	1	2
Ordinary blue dove limestone; lower portion full of gastropods; upper portion a limestone conglomerate with bunchy surface and Stromatocerium look; filling in above are 2–10 inches of shaly limestone	2	10
Thin bedded blue dove limestone	1	1
Massive blue dove limestone; few fossils and little calcite	2	......
Blue black dove limestone; full of fossils and crystallized calcite; thin bedded; shaly above	1	5
Gray, oolitic beds	2	2
Shaly, impure limestone beds blue dove color	1	4
Gray blue, subgranular limestone; calcite specks and spots	1	4
Massive, blue dove limestone; very fossiliferous; Tetradium abundant	2	10
Thin bedded to shaly blue dove limestone; mud cracked; many fossil fragments	3	6
Two massive blue dove beds with shale parting; conglomeratic; many fossils and calcite spots; not sure about Tetradium	2	8
Blue black dove limestone, notably conglomeratic; lots of fossil fragments and many calcite spots; irregular surface	....	9
Thin bedded, mud cracked, dove limestone	1	4
Blue dove limestone spotted with calcite; conglomeratic; many fossils; no Tetradium seen; abundant quartz sand grains on lower surface; probable base of Lowville	3	6
Total	54	7

A section measured by the writer 1½ miles north-northwest of Lyons Falls, and along Mill creek, shows about 54 feet of Lowville. This section is continuous with that of the Pamelia already referred to. Near Denley the section contains about 57 feet of the Lowville.

A comparison of the sections at these widely separated localities brings out some interesting facts, the chief one probably being that the formation shows almost exactly the same thickness throughout the whole distance. This is especially significant in view of the rapid thinning of the underlying Pamelia. Another fact is the great similarity of the beds in the different sections. Thus the basal conglomerate always lies from 54 to 57 feet below the summit, while another conglomerate apparently always lies about 26 or 28 feet below the summit and is associated with a heavy bed of pure dove limestone full of gastropods.

Near the west edge of the Remsen quadrangle, along Black river, there is no complete section, but the Lowville is probably not over 40 feet thick. On the Little Falls sheet the Lowville varies in thickness from 5 to 21 feet, while at Canajoharie it is absent altogether. Thus the outcropping Lowville along the southwestern Adirondacks shows a steady increase in thickness in passing from Canajoharie to Port Leyden.

Black River limestone

The Black River limestone is so named because of its typical occurrence along Black river. It is a hard, fine grained, dark colored to almost black, limestone which breaks with a smooth fracture. Interspersed through the limestone, in a very irregular manner, are small patches of black shale which causes the rock, on weathering, to break into lumpy masses. The appearance of the rock is pretty well shown in plate 6. After long exposure to the weather the surface color changes to a light gray. The rock is generally massive although two or three layers can usually be fairly well made out. Another distinctive feature of the rock, particularly he upper portion, is the presence in it of many irregular shaped black chert nodules. Among the abundant fossils are fine large pecimens of orthoceratites and columnar corals especially well exhibited on the upper waterworn surfaces. Hall[1] says of the ormation "from being characterized by a large number of peculiar ossils, though mainly belonging to a single family, it is regarded s worthy of separate notice. The principal and most prominent organic bodies in this rock are Orthocerata, some of which attain the length of more than 10 feet, and have a diameter of 1 foot or more. Associated with these are several species of Cephalopoda belonging to other genera, and some species of Gastropoda which subsequently appear in the succeeding limestone." These distinctive features cause the formation to stand out as a clearly defined horizon and there are many excellent exposures within the quadrangle.

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[1] Palaeontology of N. Y. 1847. 1:46.

Within the map limits the Black River limestone varies in thickness from 6 or 8 to 15 or 16 feet and although it is so thin it is persistently present. It is nowhere seen in outcrop on the Remsen quadrangle although it does most likely occur. In the vicinity of Little Falls it is occasionally present but only a few feet thick, while at Canajoharie it is absent altogether.

In connection with the Black River limestone certain erosion features are noteworthy. Directly overlying the hard, massive Black River beds are thin beds of Trenton with pronounced shale partings. The latter beds are more readily worn back than the former, the result being that the Black River nearly always stands out as a terrace or platform back of which the Trenton rises rather abruptly. This platform is of sufficient topographic importance to be shown on the contour map. At times of high water the Trenton is now being stripped off the Black River along Dry Sugar river and along Black river a little over a mile above the mouth of Sugar river. At the latter place the high water has cut back the Trenton limestone so as to leave a distinct and remarkably regular platform of Black River limestone which extends for several hundred yards. During low water the river occupies a channel which has been worn into the Black River limestone [*see* pl. 5].

The composition, texture, and massive character of the rock are favorable for the development of "potholes." A magnificent display of "potholes" may be seen along Sugar river (Dry Sugar river) from the canal crossing to near its mouth. The bed of the stream, which is here dry except during high water, is literally honeycombed with hundreds of "potholes," some of them attaining a depth of 6 or 8 feet and a diameter of several feet [*see* pl. 6].

Trenton limestone

The Trenton limestone has its type locality at Trenton Falls some 20 miles southward. From the standpoint of areal extent and thickness this formation is the second most important one within the quadrangle. In a general way the Trenton here shows most of the features of the type locality. At Trenton Falls the formation is about 300 feet thick and the rocks are mostly thin bedded, impure, dark limestones with pronounced shale partings, except the upper 30 feet which are thicker bedded, gray, crystalline limestones. The following section shows that a marked lithologic change has taken place in passing from Trenton Falls to Port Leyden.

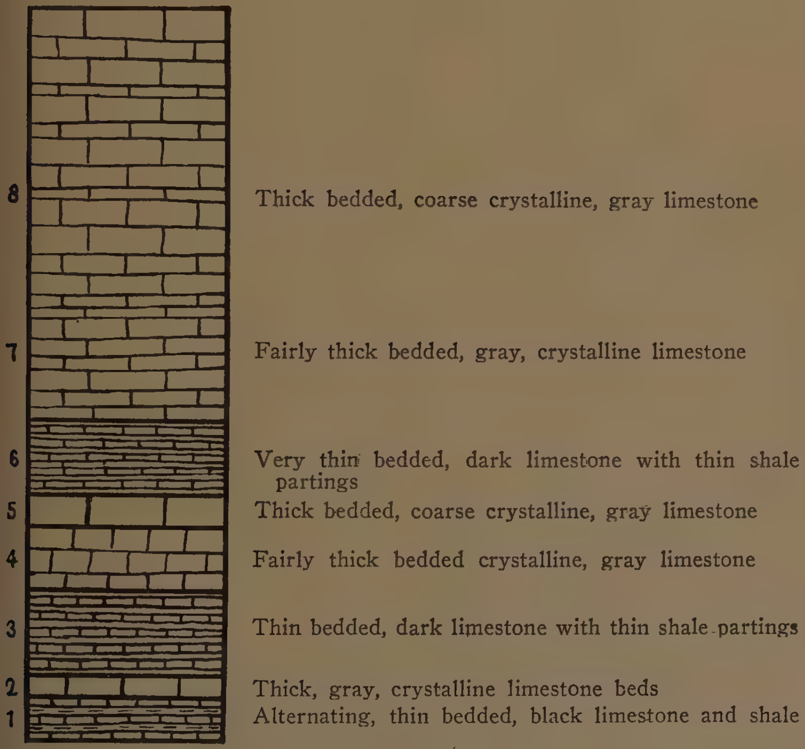
8
Thick bedded, coarse crystalline, gray limestone
7
Fairly thick bedded, gray, crystalline limestone
6
Very thin bedded, dark limestone with thin shale partings
5
Thick bedded, coarse crystalline, gray limestone
4
Fairly thick bedded crystalline, gray limestone
3
Thin bedded, dark limestone with thin shale partings
2
Thick, gray, crystalline limestone beds
1
Alternating, thin bedded, black limestone and shale

FIG. 1 Columnar section from base to summit of the Trenton limestone formation along Sugar river and Moose creek. The section is 350 feet thick.

More than half of the section is here made up of the gray, crystalline, heavy beds as opposed to only about 30 feet of such beds at Trenton Falls. Within the Little Falls quadrangle the heavy, crystalline beds are absent altogether,[1] the upper Trenton being represented by the Dolgeville shales which are in reality alternating thin beds of impure limestone and shales. These and other facts may be studied to best advantage by comparing the type section here with those of the Little Falls and Trenton Falls districts. The two last named sections may be found on page 38 of the Remsen quadrangle bulletin.[1] It is evident, therefore, that the upper Trenton sea in the Port Leyden district was much clearer water than the same sea in the Little Falls region. Also the change from the upper Trenton to the Utica was much more gradual at Little Falls as shown by the deposition there of the Dolgeville shales as a transition series. In passing northward from Sugar river to Martinsburg the pure, heavy bedded, crystalline limestones assume even greater importance.

The lowermost 20 feet of the Trenton are highly fossiliferous, thin bedded, alternating shales and limestones. These beds are in sharp contact with the underlying massive Black River limestone as may be seen along Sugar river; along Black river 1 mile above the mouth of Sugar river; along Mill, Douglass, and House creeks and Roaring brook.

Except for the shale area at Locust Grove, the Trenton limestone extends from south to north across the map as an unbroken belt whose width is from 2 to 3 miles. It forms the summit of the lower great terrace so plainly shown on the topographic map. Minor terraces are developed along the lines of outcrop of certain harder and more resistant strata within the formation. The villages of Talcottville, Collinsville, Turin, Houseville and Martinsburg all rest upon the Trenton. The larger streams have cut picturesque gorges through this limestone as for example on Sugar river, Mill creek, House creek and Roaring brook. The last named gorge is locally called " Whitaker's gulf."

Throughout all of Trenton time the ocean was fairly teeming with animal forms, especially brachiopods, trilobites, cephalopods, corals and crinoids. Many of the limestone beds are practically made up of fossil shells. The writer has made no detailed study of the fossils, but the forms are mostly the same as those decribed by Prosser and Cumings from the type locality at Trenton Falls. Hall has described and figured many of the forms from this limestone along the Black river valley. In the lowest Trenton beds the writer has seen specimens of orthoceras several feet long and 5 or 6 inches in diameter.

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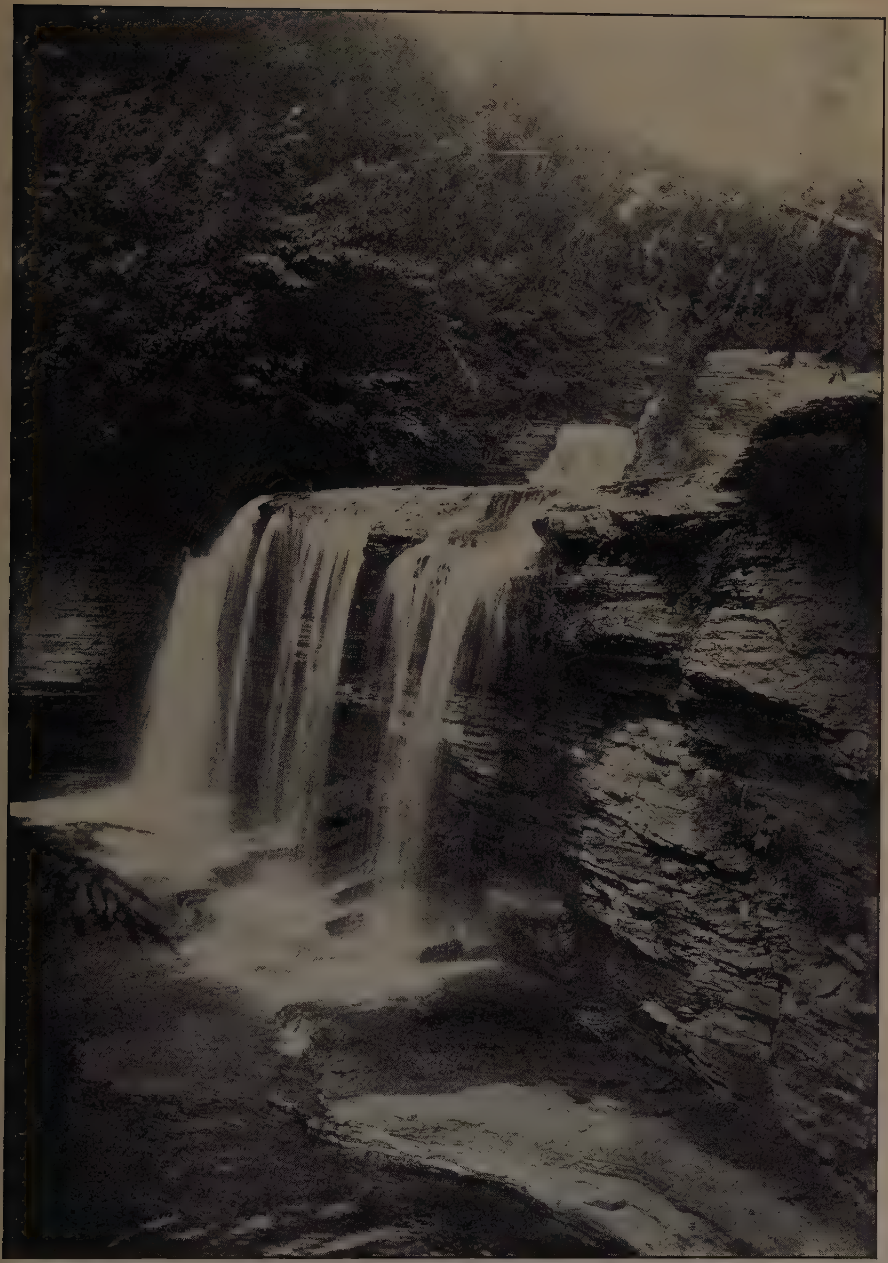
[1] N. Y. State Mus. Bul. 126. p. 38.

Plate 8



Whitaker falls on Roaring brook 1 mile southwest of East Martinsburg station. The rock is Trenton limestone.

The thickness of the Trenton has been approximately determined in a number of places as follows:

	Feet
Along Moose creek and Sugar river	350
Between Port Leyden and Locust Grove	370
Along Mill creek	400
Along House creek	450
Along Roaring brook and Atwater creek	475

Thus, in a distance of 20 miles across the map, from south to north, the Trenton shows an increase in thickness of something like 125 feet or at the rate of about 6 feet per mile. Passing southeastwardly along the line of outcrop, the Trenton shows a progressive thinning. Thus at Remsen it is about 300 feet; near Middleville 200 feet; at Ingham Mills 100 feet; and at Canajoharie only 17 feet. Westward in Oswego county deep wells at Stillwater and Central Square show respective thicknesses of 670 and 747 feet.

Utica shale

The Utica shale formation shows practically the same characteristic features here as it does at its type locality at Utica. It is a very fine grained, dark gray to black, thin bedded shale. The black color is due to the presence of carbonaceous matter which may be readily burnt out, although, contrary to a current popular idea, nothing like a workable coal seam occurs within the formation Occasionally some of the layers are rather sandy especially toward the top. Toward the base of the formation some of the layers are several inches thick and are frequently calcareous and except for this the contact between the Utica and the Trenton is a sharp one. Because of the softness of the rock and the character of the outcrop, favorable to the development of talus slopes, the actual contact between the shale and limestone was nowhere observed. Many times, however, Trenton beds have been noted in such close proximity to the shale that the boundary line can be pretty accurately drawn. Such observations may be made along Atwater creek or Moose creek.

In spite of a considerable thickness its areal extent is rather small because it outcrops along the base of the steep slope forming the eastern fronts of Tug and Mohawk hills. Excellent sections are to be found along all of the larger streams which cut across this steep slope. Its broadest surface exposure is from Constableville southward where the shale is thickest and the slope is not so great. An interesting erosion remnant, or outlier, separated from the main mass covers several square miles in the vicinity of Locust Grove.

The Utica shale is here not highly fossiliferous although certain fossils so common to the formation may be found in nearly every exposure. Among these are the Endoceras proteiforme of the chambered cephalopods, Triarthrus becki of the trilobites, and some graptolites. Animal life in the Trenton ocean was very prolific, but with the advent of the muddy Utica sea there was a great diminution in both the number of species and individuals.

Along the line of outcrop the shale shows a notable and steady decrease in thickness toward the north. Following are approximate determinations of the thickness within the quadrangle from south to north.

	Feet
Along Moose creek	300
At Constableville	260
At Turin	230
At Houseville	200
Along Atwater creek	180

Southeasterly along the line of outcrop the Utica increases in thickness. Near Remsen it is over 300 feet and near Little Falls about 600 feet. Westward in Oswego county it shows a thickness of 180 feet at Central Square; 120 feet at Fulton and 113 feet at Stillwater in the deep wells. Thus it is evident, in a general way along the southwestern Adirondacks, that the Utica is thinnest where the Trenton is thickest and vice versa, the two formations having nearly the same thickness on the Remsen quadrangle.

Lorraine shales and sandstones

The Lorraine formation received its name from the town of Lorraine in Jefferson county, some 30 miles northwest of Port Leyden. The rocks included under this heading are the same as those of the old "Hudson River group" of Vanuxem's report.[1] In the future the Lorraine beds will doubtless be subdivided, but more detailed work over a wider territory must be done before such subdivision is attempted. In the meantime, all the strata lying between the

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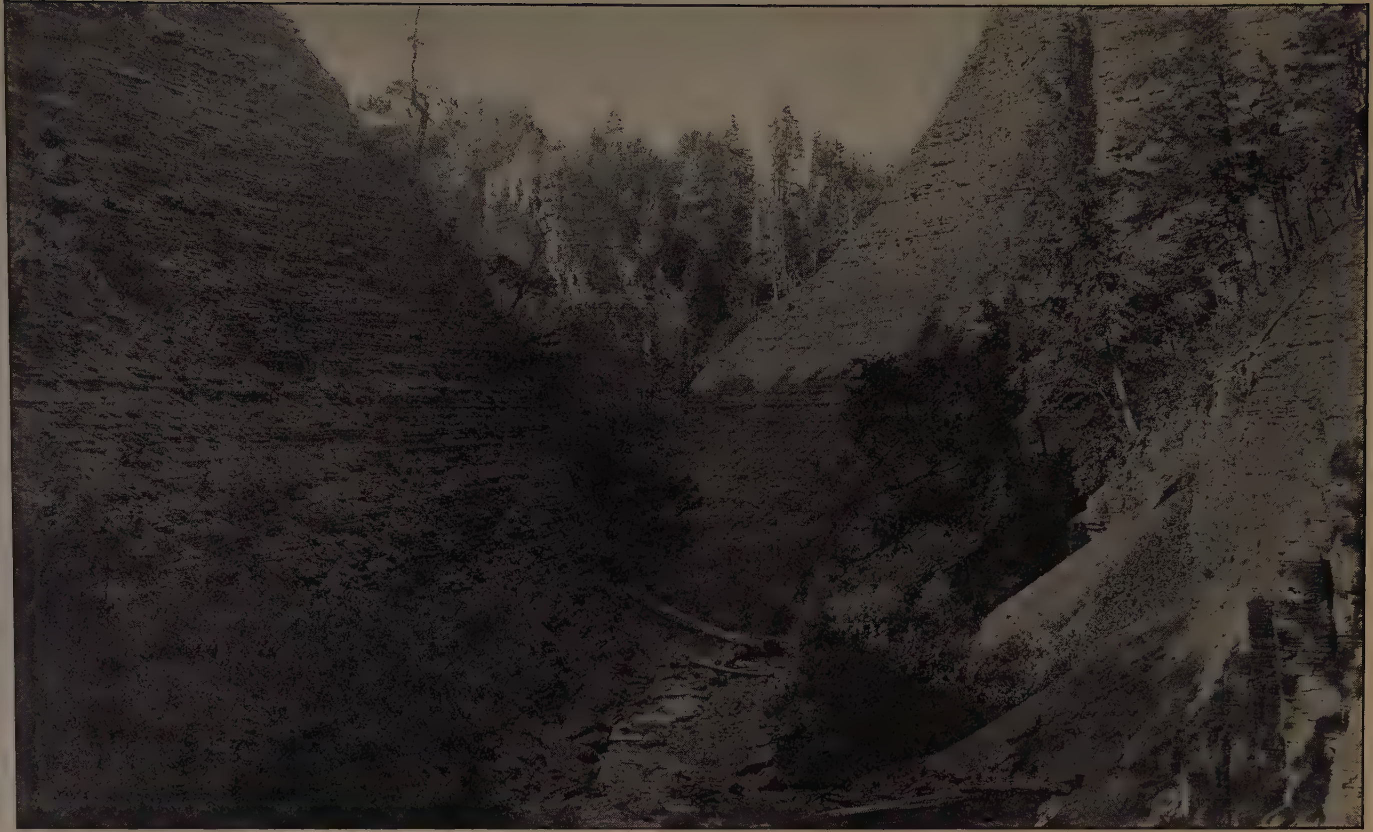
[1] Geol. N. Y. 3d Dist. 1842. p. 60.

Plate 9



A view in Whetstone gulf. A short distance above this the gulf is much narrower. The depth is nearly 300 feet and the exposed rocks are the alternating shales and sandstones of the Lorraine.

Utica shale and the Oswego sandstone, two well marked horizons, are described and mapped in this report as Lorraine.

The formation consists chiefly of alternating thin bedded shales and sandstones together with some thin layers of limestone. There is no sharp line of separation between the Utica and the Lorraine, the lowermost shale beds of the Lorraine being in every way like those of the Utica. The lower Lorraine, comprising a thickness of approximately 200 feet of shales, is not very fossiliferous and contains occasional thin beds of fine grained sandstone. Among the fossils the Endoceras proteiforme and Triarthrus becki, so common in the Utica shale, are also found here. The lower Lorraine as thus described corresponds in a general way at least to Vanuxem's Frankfort slate and sandstone.[1]

The upper Lorraine, showing a thickness of something over 400 feet, is made up of gray, fine grained sandstone beds alternating with black to dark gray shales and occasional thin beds of impure limestone. Passing upward the sandstone content increases greatly and the thin partings of shale become rather sandy and light colored. The upper Lorraine sandstones and limestones are highly fossiliferous and fragments of sandstone full of fossils are strewn over the Tug hill region in great quantities. Among the many fossils some of the more noteworthy forms are: Pentacrinites hamptonii of the echinoderms, Leptaena sericea and Orthis testudinaria of the brachiopods, Ambonchyia radiata and Modiolopsis modiolaris of the lamellibranchs and Cyrtolites ornatus of the gastropods. A more complete list of fossils for this general region may be found in a paper by Walcott.[2] The upper Lorraine as here described corresponds roughly to the sandstone shale of Pulaski as used in Vanuxem's report.

From the standpoint of both areal extent and thickness the Lorraine is the principal Paleozoic formation of the quadrangle. Except for the small Oswego sandstone area, the Lorraine occupies all of Tug and Mohawk hills. Fine sections are exposed along the larger streams which cut across the eastern front of Tug hill, the best one probably being in Whetstone gulf [*see* pl. 9]. The whole thickness of the formation is shown in the township of Turin where it is estimated at 630 feet. About 600 feet are shown in Mohawk hill with the top not present. Well records to the west and south show the Lorraine to be 600 feet thick at Lorraine (Jefferson co.); 530 feet at Stillwater (Oswego co.); 549 feet at Central Square (Oswego co.); 640 feet at Chittenango (Madison co.) and 720 feet at Vernon (Oneida co.). According to these figures there is somewhat of variation in thickness but not in any particular direction.

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[1] *loc. cit.* p. 61.

[2] Geol. Soc. Am. Bul. 1890. 1:348-49.

Oswego sandstone

This formation is so named because of its prominence in Oswego county. It is the only representative of the Upper Siluric within the quadrangle, and corresponds to the gray sandstone of Oswego as used in Vanuxem's report. But one small area occurs within the map limits and this forms the capping of the highest part of Tug hill. This area represents the easternmost extension of the formation which occupies many square miles in the southern part of Lewis county. The Highmarket quadrangle, immediately to the west, is literally strewn with slabs of this sandstone and the region is characterized by numerous swamps and a sluggish drainage.

Within the map limits the Oswego sandstone is a gray, fine grained, thin bedded rock. The stratification is not very regular and practically no shale is present. Fine examples of cross-bedding on a small scale are common. A characteristic feature is the presence of occasional yellowish spots of limonite, which are no doubt due to the alteration of original iron pyrite. In marked contrast to the underlying formation, the rock examined appeared to be barren of fossils. The sandstone lies between the 2000 and 2100 foot contours, thus showing a thickness of about 100 feet but with the top not reached.

STRUCTURAL GEOLOGY

Dip of the Paleozoic formations

Movements since the deposition of the Paleozoic strata have given them a very perceptible dip toward the southwest. This dip may be determined, in a general way at least, by comparing the altitudes of given horizons within the Port Leyden quadrangle and south and west. For this purpose the top of the Trenton is chosen because it is so clearly recognized in well sections.

The top of the Trenton in the Rome well, as reported by Prosser,[1] is 205 feet below sea level, while 2 miles west of Port Leyden it is

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[1] Am. Geol. 1900. 25:137.

1280 feet above sea level. Thus in a distance of 25 miles the top of the Trenton drops 1485 feet or shows a southerly dip of nearly 60 feet per mile.

According to Orton,[1] the top of the Trenton in the Central Square (Oswego co.) well was struck at 1209 feet below sea level. The same horizon 2 miles west of Port Leyden is at an altitude of 1280 feet above the sea which thus shows an increased elevation of 2489 feet within 44 miles or a southwesterly dip of over 56 feet per mile.

In the Stillwater (Oswego co.) well Orton[2] reports the surface of the Trenton at 25 feet below sea level and this is 1305 feet below the same horizon 2 miles west of Port Leyden. The distance is 30 miles and the westward dip is over 43 feet per mile.

Within the map limits, near Locust Grove, the Trenton-Utica contact is at an elevation of nearly 1300 feet, while 2 miles to the southwest it is a little over 1100 feet, thus indicating a southwestward dip here of about 50 feet per mile.

An exceptional dip of 3 or 4 degrees toward the southwest may be seen in the Trenton limestone in the vicinity of Martinsburg. This is probably due to the updrag effect of the fault below described.

Faults and folds

No fault of sufficient extent to be mapped has been found within the limits of the quadrangle. A few places have been noted where there have been slight movements of 1 or 2 feet as for example in the Trenton of the Black river gorge 2½ miles northeast of Boonville.

Just beyond the edge of the map and in a ravine ¾ of a mile northwest of East Martinsburg station a fault with considerable displacement is well shown. No detailed study of this fault has been made, but it is of the normal type and strikes approximately northwest-southeast. Its length was not determined. The fault plane stands nearly vertical and the limestone beds are highly inclined on the south side as a result of the updrag during the process of faulting. On the north side of the ravine the Precambric lies fully 40 or 50 feet higher than on the south side and this represents the amount of the throw. The Pamelia beds have been faulted against the Precambric. The unusually rapid downward slope of the Precambric surface between Glenfield and East Martinsburg is due to the settling of the mass on the south side of the fault.

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[1] N. Y. State Mus. Bul. 30. 1899. p. 455.

[2] *loc. cit.* p. 448.

Extensive folding of the Paleozoic rocks nowhere occurs. Local folds are sometimes developed but even these are rare. Such small folds are best seen ½ mile above the mouth of Mill creek (north of Boonville); near Denley; and where the railroad crosses Sugar river. At the latter place a syncline in the Trenton is perhaps the best example of folding in the district.

The folded structure of the Precambric rocks will be dealt with under the heading "Gneissic structure."

Ripple marks

Small ripple marks are frequently present in the Paleozoic formations. Thus at several horizons within the Pamelia, Lowville and Trenton limestones there are ripple marks which measure 1 or 2 inches from crest to crest and about ½ inch from trough to crest. Special attention, however, is called to certain ripple marks of unusual interest in the Trenton. They are of unusual interest both because of their large size and their occurrence in limestone. These marks occur about 25 or 30 feet above the base of the Trenton and are finely shown in the south bank of Sugar river a short distance above the railroad bridge. The ripples measure from 24 to 56 inches from crest to crest, and 4 to 7 inches from trough to crest. They strike about n. 30° e. The ripple marked layer varies in thickness from 2 to 9 inches and is a crystalline and very fossiliferous limestone. Shale occurs immediately above and below the marked stratum and the shale above thickens or thins according to whether it rests upon the troughs or crests of the ripples. The limestone layers both above and below rapidly thicken and thin and are certainly of shallow water origin.

Gneissic structure

The precambric rocks, which are metamorphosed, igneous and sedimentary masses, all exhibit the gneissic structure. This structure is best developed in the old Grenville sediments and least in the syenite. In the areas of mixed gneisses it is also clearly shown. The strike of the gneissic bands varies from north-south to almost east-west, but the most common range is from n. 40° to 70° e. The direction of dip of the foliation planes is either northward or southward but prevailingly northward. The angle of dip is usually high, varying from 50 to 80 degrees although just north of Lyons

Falls it is as low as 20 or 25 degrees. From south of Denley to 3 miles north of Lyons Falls the dip is northward; thence northward to just south of Glenfield it is southward; thence northward to the map limit it is northward. Thus we have good evidence of distinct folding of the Precambric rocks on a large scale. Certain other Precambric rock structures will be discussed later.

Structure sections

The structure sections shown in figures 2–4, page 38, have been carefully chosen with the idea of giving the best general notion of the various rock formations and their relationships to each other.

PALEOZOIC OVERLAP

It is well known that during the general subsidence (barring certain minor oscillations of level) of the Adirondack region in early Paleozoic times, sediments were being deposited on the Precambric surface and that these sediments gradually encroached upon the sinking land mass until nearly all, if not all, of the Adirondack region was covered by them. The younger formations extended farther in than the older ones upon the sinking surface, thus constituting an overlap of the Paleozoic sediments upon the Precambric crystallines. The stripping off of this Paleozoic cover has been going on since the close of the Paleozoic era, at least, and the exposed surface of the Precambric rocks is still being enlarged by this same process. A glance at the structure sections [fig. 2–4] will show the eroded edges of about 1500 feet of sediments which formerly must have extended farther eastward upon the Precambric surface. In the Port Leyden district we have positive evidence to prove the Paleozoic overlap.

On the western side of the Adirondacks the oldest overlapping formation is the Potsdam sandstone. It is not present in outcrop within the Port Leyden quadrangle, the nearest exposures being about 20 miles northward in the vicinity of Carthage. According to Orton[1] the Potsdam, resting upon the Precambrics, occurs in Oswego county to the west and southwest of Port Leyden as shown in deep well sections. Thus the deep well at Central Square shows 156 feet of sandstone; the well at Parish 50 feet of sandstone and the well at Stillwater (southeast of Orwell) at least 49

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[1] N. Y. State Mus. Bul. 30.

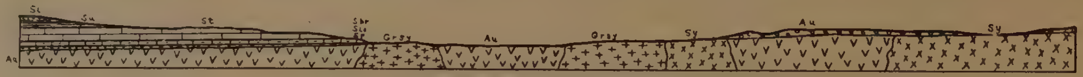

FIG. 2. SECTION AB.

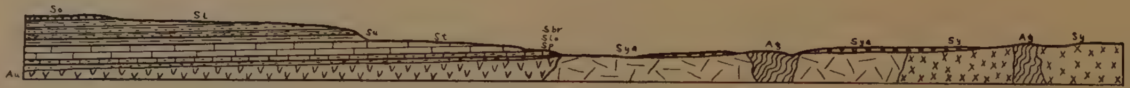

FIG. 3. SECTION CD.

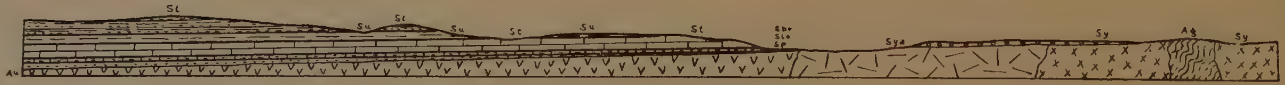

FIG. 4. SECTION EF.

FIG. 2–4 Structure sections across the Port Leyden quadrangle. The section lines are indicated on the geologic map. The symbols are the same as those on the geologic map. Vertical scale is twice the horizontal.

feet of mostly sandstone. Orton refers all of these sandstones to the Potsdam. The bottom of the section at Stillwater is:

	Feet
Dark Trenton	370
Sand and shales	40
Sand, green and white	25
Black limestone	6
Red and white sandstone, calcareous	18
Precambric struck at	1697

Fossils in the black limestone layer prove the Upper Cambric (Potsdam) age of the deposit. The presence of this Potsdam in Oswego county and its absence along the Paleozoic-Precambric boundary to the eastward on the Port Leyden sheet, affords conclusive evidence of overlap.

Again, we have a strong argument in favor of overlap if we consider the whole thickness of sediments between the top of the Trenton and the Precambric. Details will be presented later, but suffice it to say now that a comparison of the thickness of these sediments in Oswego county with those near Port Leyden shows a thinning of several hundred feet in passing toward the latter place. Such a marked diminution in thickness toward the northeast and east is just what would be expected in the case of overlap.

SURFACE OF THE PRECAMBRIC ROCKS

Smoothness of the surface which received Paleozoic deposition

A study of the Paleozoic-Precambric line of contact gives strong evidence in favor of the statement that the sinking surface which received Paleozoic sedimentation must have been worn down to a remarkably smooth condition (peneplain). Except for a few miles near the southern edge of the map, the Paleozoic-Precambric boundary line can be drawn with a considerable degree of accuracy. A glance at the geologic map will show that this boundary line is a very regular one which at no point shows any rapid elevation or depression. Such a regular line of contact is precisely what one would expect where sediments have been laid down upon a smooth floor and then, after elevation, have been stripped off rather regularly by erosion. Even a comparatively small elevation or depression along the contact line could be recognized. At several points where the actual contact is exposed, the Precambric floor appears to be smooth.

Because of the deep mantle of sand and gravel which now covers the Precambric surface east of Black river, the configuration of that surface can not be studied to the best advantage. But so far as can be judged, if the stream channels in the Precambric surface were filled up the resulting surface would be comparatively smooth and even which strongly argues for that sort of a surface before the stripping off of the sediments and later erosion. Any prominent elevations on the old floor ought now to be recognizable, especially in the valley bottom and near the Paleozoic boundary, but none occur there. The distinct rock ridge southeast of Fowlersville seems to be the only example of such an elevation. This ridge rises about 80 feet above the general level but its hight is thought to have been somewhat accentuated by ice action. Again, if there had been any marked depressions in the old floor they would have been filled up with Paleozoic sediments and we might well expect to find such protected sediments as isolated patches or outliers within the general Precambric area as, indeed, the Potsdam sandstone does occur some 30 or 40 miles farther northward. The available evidence, however, points to a complete removal of the sediments.

The conclusion for the Port Leyden quadrangle is that the Precambric floor upon which the sediments were laid down was comparatively smooth and even, with only one known elevation rising above the general level. This is substantially the conclusion reached by Professor Cushing and the writer for the Little Falls and Remsen quadrangles respectively and it is true of the southern and southwestern border of the Adirondacks. This result as Cushing says "seems specially important in view of the fact that Professors Kemp and Smyth, and the writer (Cushing) also, have found evidence to show that, in the St Lawrence and Champlain valleys and vicinity, the surface on which the Potsdam was deposited was considerably more uneven than this. In other words, the surface to the south was worn down to a nearer approach to base level than was the case farther north."

Slope of the Precambric surface where now exposed

We have just shown that the Paleozoic sediments were deposited upon a very smooth Precambric surface. The uneven and dissected character of that surface where now exposed is due almost entirely to erosion since the stripping away of the sediments. A fairly good idea of the present general slope of this surface may be obtained by comparing altitudes at various points.

Near Partridgeville the Precambric lies at about 1300 feet above the sea level, while at Hawkinsville (Boonville sheet), 16 miles southward, it lies at 1060 feet. The difference in elevation is 240 feet or the slope per mile southward is 15 feet between these places.

One mile south of Donnattsburg the Precambric is at 1020 feet, while at Port Leyden, 10½ miles southward, its elevation is 900 feet. The difference in elevation of 120 feet shows a southward slope of over 11 feet per mile in this direction.

The Precambric near Partridgeville is at 1300 feet, while just west of Glenfield, 7½ miles westward, it lies at 840 feet. Thus we get a difference in elevation of 460 feet or a slope per mile of 61 feet toward the west. In a similar way we may find a slope, between Lyons Falls and a point east of Fowlersville, of 67 feet per mile westward.

In the vicinity of Woodhull lake, at the western edge of the Old Forge sheet, the Precambric elevation is 2000 feet while at Port Leyden, 17 miles westward, it is 900 feet. The difference in altitude is 1100 feet which means a westward slope of nearly 65 feet per mile.

These comparisons clearly demonstrate that the Precambric surface now slopes both southward and westward, but that the westward slope is much steeper. The writer has compared Precambric altitudes at many points over the Port Leyden, Remsen, Wilmurt and Little Falls quadrangles. The conclusion reached is that the exposed Precambric surface along the southwestern Adirondacks slopes both westward and southward; that the slope toward the west is steeper (being from 60 to 100 feet) than the slope toward the south (being from 11 to 50 feet); and that the general southwestward slope is greater in the Little Falls than in the Port Leyden region.

Slope of the Precambric surface where Paleozoics now cover

Having acquired some idea regarding the slope of the exposed Precambric surface it will now be of interest to determine the slope of the Precambric surface where Paleozoics now cover. This may be done by comparing altitudes of the Precambric within the Port Leyden quadrangle with the Precambric altitudes as found in certain deep wells to the south, southwest and west.

In the Campbell well 3 miles west of Utica, according to Prosser,[1] the Precambric was struck at 1500 feet below sea level, while at

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[1] Geol. Soc. Am. Bul. 1893. 4:101.

Port Leyden it lies at 900 feet above sea level. The distance is 33 miles and the difference in elevation 2400 feet which shows a slope of over 72 feet per mile southward.

According to Orton,[1] the Central Square (Oswego co.) well shows Precambric at 2015 feet below sea level, while at Port Leyden its altitude is 900 feet. This shows a drop of 2915 feet in passing 46 miles southwestward or a slope of over 63 feet per mile toward the southwest.

In a deep well at Pulaski the Precambric was struck at 1048 feet below sea level, according to Orton.[2] Its altitude at Port Leyden is 900 feet, which indicates a drop of 1948 feet in a distance of 38 miles or a slope of over 51 feet per mile toward the west.

These results show that the Precambric slope under the Paleozoics is somewhat greater southward than westward and that the general southwestward slope is clearly less than it is in the Little Falls and the Remsen districts. Also the slope under the Paleozoics is greater than where no sedimentaries now cover, which is always true along the southwestern border of the Adirondacks. This is what would be expected because the general surface over the Precambric area has been reduced by erosion since the removal of the sediments. By referring to the above figures we find that if we consider a due east-west line through the Port Leyden district, the Precambric slope under the Paleozoics is actually a little less than it is east of them. This certainly means that the slope of the Precambric surface, before the removal of the sediments, must have been steeper eastward from Port Leyden than westward, and that it is still steeper in spite of the later erosion.

Slope of the Precambric surface during Paleozoic deposition

It is possible to get some idea regarding the slope of the surface upon which the older Paleozoics were being deposited by comparing the thickness of these formations with the same ones to the west and southwest in Oswego county. This comparison may be most satisfactorily made by considering together all of the deposits from the top of the Trenton to the Precambric, because in the well sections the different formations are not clearly distinguished.

In the well at Pulaski[3] the thickness of the strata from the top of the Trenton to the Precambric is 900 feet, while the corresponding thickness just west of Port Leyden is only 500 feet. Between these places, which are 39 miles apart, the thickness has diminished 400 feet or at the rate of over 10 feet per mile toward the east.

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[1] *loc. cit.* p. 455.
[2] *loc. cit.* p. 489.
[3] *loc. cit.* p. 489.

At Central Square it is 806 feet from the top of the Trenton to the Precambric, while at Port Leyden it is 500 feet. Thus in a distance of 45 miles the thickness has diminished 306 feet or at the rate of nearly 7 feet per mile toward the northeast.

In the Stillwater well the top of the Trenton lies 772 feet above the Precambric, while at Martinsburg it is about 600 feet. This shows a decreased thickness in 27 miles of 172 feet or at the rate of over 6 feet per mile toward the northeast.

Thus we see that there is an increasing thickness of these formations toward the southwest and west at from 6 to 10 feet per mile, and these figures may, in a general way at least, be taken to indicate the slope of the surface upon which the Paleozoic deposits were being laid down.

These results are significant when compared with the results similarly obtained by Cushing for the Little Falls district and by the writer for the Remsen quadrangle. In the Little Falls region the slope receiving Beekmantown deposition was about 30 feet per mile southward; while in the Remsen district the slope receiving Trenton deposition was from 6 to 20 feet per mile southwestward, the greatest slope being in the southeastern portion of the district. Thus it is pretty well established that the slope of the surface receiving Paleozoic deposition was very considerably greater in the vicinity of Little Falls than in the vicinity of Port Leyden and that there was a gradual change from the steeper to the more nearly level surface.

The results obtained for the Port Leyden quadrangle are also significant in another way. The thickness of the formations here, from the top of the Lorraine to the Precambric, is approximately 1400 feet. This thickness is great enough so that even after allowing for decreased thickness due to overlap and a possibly increased slope (receiving sediments) as the heart of the Adirondacks was approached, we seem to have here a strong argument in favor of the submergence of the region for many miles to the east and northeast of Port Leyden, so that by the close of the Lower Siluric the submergence extended to, or close to, the heart of the Adirondacks. This conclusion is quite different from that reached by Cushing by similar reasoning for the southern Adirondacks. He says:[1] "This line of evidence would therefore, so far as it may be worth anything, seem to indicate that the southern Adirondack region could not have been completely submerged at the close of the Lower Silurian, much less so at the close of the Trenton."

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[1] N. Y. State Mus. Bul. 77. 1905. p. 61-62.

PLEISTOCENE (GLACIAL) GEOLOGY

From the standpoint of its glacial history the Port Leyden district is unusually interesting and instructive. When the great ice sheet, which covered most of New York State, reached its maximum development the Black river valley must have been buried under several thousand feet of ice. We know this because the whole Adirondack region is glaciated and was covered by the ice. The advance and retreat of the ice across the Port Leyden quadrangle has left most of the ordinary marks of glaciation, while certain of them are developed to a remarkable degree. So far as the writer knows nothing has been published regarding the Pleistocene history of this immediate region, although a report by Chamberlin[1] published some 27 years ago has an indirect bearing.[2]

Direction of ice flow

Chamberlin, in the report above referred to, makes the tentative statement "that massive ice currents having their ulterior channels in the Champlain valley, on the one hand, and the St Lawrence on the other, swept around the Adirondacks and entered the Mohawk valley at either extremity, while a feebler current, at the hight of glaciation, probably passed over the Adirondacks and gave to the whole a southerly trend." Observations by later investigators have tended to bear out this view and the evidences from the Port Leyden quadrangle herewith presented have an important bearing upon the proposition.

The direction of flow is best shown by the glacial striae which have been observed at a number of different places through the district. The striae are best preserved upon the hard Precambric rocks, but these are mostly drift covered except along the chief stream courses. The limestones are next most favorable while upon the shales none have been found. Striae are present only upon those surfaces from which the drift has been recently removed, because even the hardest rocks, exposed during all of postglacial time, have been weathered enough to cause an obliteration of the glacial marks.

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[1] U. S. Geol. Sur. 3d An. Rep't 1881–82. p. 360–65.

[2] Since the above was written Prof. H. L. Fairchild has presented several papers, bearing on the glacial history of northern and central New York, before the 1908 meeting of the Geological Society of America. These papers will be published in the bulletin of the society.

Striae pointing from s. 25° to 40° e. have been located as follows: On Trenton limestone 1 mile south of Martinsburg and also ⅓ mile to the east of that village (s. 25° e.); on Black River limestone just west of Lyons Falls; on Precambric near the mouth of Roaring brook, 1½ miles northeast-north of Glenfield and also ⅓ mile southwest and ¾ mile southeast-south of the same village; on Precambric 1 mile northeast of Denley and ⅓ mile northeast of Hawkinsville. Striae bearing nearly south occur on the Precambric 1 mile east of Port Leyden. The southeasterly movement, shown by these marks, changed to a more nearly easterly movement in the Mohawk valley region, and this is just what would be expected according to the statement of Chamberlin. It should be noted that the Black river valley, which is the chief topographic feature on the western side of the Adirondacks, had much to do with determining the direction of flow of the ice. This valley existed in preglacial time and the close parallelism between the directions of the striae and the direction of the valley shows the influence of the latter in determining the ice movement. Along the northwestern border of the Adirondacks the ice undoubtedly moved southwestwardly. Along the eastern border of the Adirondacks the general southerly movement of the ice has been well established, as has also the westerly movement up the Mohawk valley toward Little Falls. Thus the statement of Chamberlin, regarding ice flow around the Adirondacks, harmonizes almost perfectly with the observed striae.

But the question still arises, what was the direction of the current during the hight of glaciation? We have abundant evidence to prove that, during the hight of glaciation, the main current was a southeasterly one. On the Long Lake quadrangle in the midst of the Adirondacks Professor Cushing has recorded a number of striae all of which point toward the southwest.[1] Over the region south of the Adirondacks and the Mohawk valley the observations of both Brigham[2] and Chamberlin[3] show that the ice moved in a general southwesterly direction. Another strong evidence favoring the southwesterly current is the distribution of glacial boulders over the region southwest of the Adirondacks. Most of the common Adirondack rock types are strewn over the region and they gradually diminish in number as the distance from the mountains becomes greater. This subject has been discussed in a paper by Brigham.[1]

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[1] N. Y. State Mus. Bul. 115. 1906. p. 495.

[2] Amer. Jour. Sci. 1895. 49:216.

[3] *loc. cit.* p. 365.

Thus, bearing in mind all the facts, the writer is strongly of the opinion that when the ice in its southward movement struck the Adirondacks, it was divided into two currents flowing around the mountains and meeting in the Mohawk valley; that during the time of maximum glaciation there was a strong general southwesterly current, but that the border currents continued as under currents (more or less checked in velocity); and that after the disappearance of the ice sheet from the central Adirondacks, border currents were maintained. According to this the Port Leyden quadrangle was first invaded by a tongue of ice which flowed southeastward up the Black river valley. When the general ice sheet had here reached a thickness of several thousand feet the main current was southwesterly, but with a southeasterly under current in the valley bottom. The ice first melted from the highlands and left a tongue of ice in the valley which gradually melted and retreated northward.

ICE EROSION

Erosion of the Precambric rocks

As the ice moved across the quadrangle, the preglacial rock surface was more or less scratched, polished and eroded. In the case of the Precambric rocks it is doubtful if the ice did any very deep cutting. Its work of erosion involved mostly the removal of masses of decayed and weathered rock material near the surface. The evidence is conclusive that the weathered materials were rather thoroughly scraped off the Precambrics as shown by the remarkable freshness of the rocks wherever exposed and by the smoothed and rounded character of the outcrops [*see* pl. 3]. The highly jointed character of these rocks no doubt greatly aided the ice in its work of erosion. Mention should be made of the great number of erratics of Precambric rock material strewn over much of the region, especially toward the south. One of these erratics measures about 17 feet high and 27 feet across [*see* pl. 11]. The larger ones are mostly of the hard, homogeneous syenite or granite. Probably the greatest amount of erosion of the Precambrics occurred along Black river between Lyons Falls and Lowville, but this matter will be referred to below.

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[1] *loc. cit.* p. 213–28.

Erosion of the sedimentaries

Turning our attention to the sedimentaries, we find that ice erosion was much more effective upon them. In fact the writer believes that in the Black river valley we have one of the best examples of ice erosion in northern New York. One factor favoring the ice work here was the comparative softness and highly jointed character of the rocks, while another factor was their position with reference to the ice current.

The figure on page 48 shows the profile and geologic structure across the Black river valley 2½ miles north of Lyons Falls. One of the striking features is the terraced character of the sedimentaries, particularly from Port Leyden northward [*see* topographic map]. Along the river course there is a slight notch in the Precambrics and just west of this, on the northern part of the Port Leyden sheet, there is a steep slope rising 300 feet above the Precambrics. The formations outcropping on this slope are shown in the section. Resting upon the Precambrics are several feet of weak sandstones which are followed by the sandy limestones of the Pamelia; then come the hard Lowville and Black River limestones; while the summit is capped by hard, crystalline limestones. The streams passing over this slope are characterized by gorges with waterfalls and rapids. From the summit of this slope and extending for several miles westward there is a well defined terrace developed upon the limestone.

Rising from the western side of the above named terrace there is a second slope higher and much steeper than the first. The rise is commonly about 450 feet within ⅓ mile. The soft Utica shales outcrop at the base of this slope and they are followed by the Lorraine shales with an upward increasing sandstone content. The summit of this terrace, known as Tug hill, is more irregular and stream dissected than the limestone terrace below. All streams flowing across the steep slope of this terrace have high gradients and have cut deep, narrow gorges locally called "gulfs."

At first these terraces, in their present form, were thought to have been due entirely to water action, but an examination of the region shows that some other explanation must be sought. The steep fronts of the terraces are certainly young topographic features, which precludes the possibility of their having been formed during the long preglacial period of erosion in this ancient region. On the other hand, Black river has done very little work of erosion, between Lyons Falls and Lowville, in postglacial times as proved by the fact

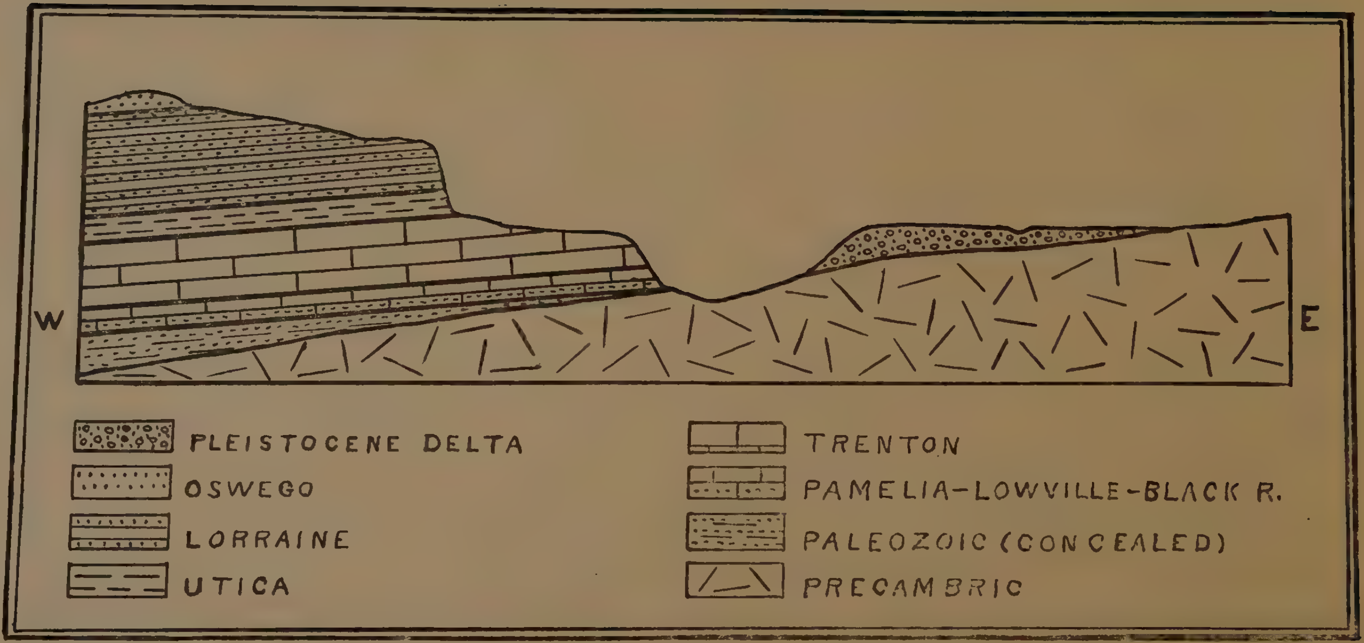

FIG. 5 East-west section across the Port Leyden quadrangle 2½ miles north of Lyons Falls, showing the position of the delta deposits and the terraced character of the Paleozoic sediments. Vertical scale 8.8 times the longitudinal.

that the stream has not yet cut its way through the alluvium and reworked drift filling the valley bottom, and also because glacial striae and kames near the river level have not been disturbed. Thus also the slight trench cut into the Precambrics along here could not have been postglacial in origin.

There is still the possibility that glacial waters might have developed the terraces, but there is no evidence of any such vigorous water action especially along the higher part of the limestone terrace where records would surely be left. Even if a large stream had flowed along the ice edge and under the steep front of Tug hill its gradient would have been too low to be compatible with much cutting power. No doubt there was movement of water along the waning Black river ice lobe, but the only current of any importance was a northerly one between the eastern edge of the limestone terrace and the ice margin [*see* below]. The limestones here are somewhat water-worn, but the stream was about 200 feet below the top of the terrace and thus clearly could not have done the work of erosion over the whole terrace. Also the presence of glacial striae on the terrace shows that no great amount of erosion could have taken place there since the ice retreat.

It seems certain that the lowermost Paleozoic layers must have extended farther eastward, by overlap on the Precambrics, immediately preceding the glacial period. This means that Black river was some distance farther eastward and that the western tributaries from Tug hill entered it with lower gradients. As above shown, the lowest sedimentary beds could not have been cut back to form the steep slope now facing Black river in pre- or postglacial times nor were they cut back by glacial waters. Evidently they were cut back by the ice to develop the steep slope. This allowed Black river to shift westward to its present position. Thus the slight trench in the Precambrics here could not have been preglacial. As already shown it is clearly not postglacial and apparently it was formed by ice cutting. The concave character of this inner portion of the valley is brought out in the figure and strongly suggests ice work.

The fact should also be considered that we are here dealing with unaltered sedimentaries, with slightly upturned edges, resting upon a rather smooth surface of igneous and metamorphic rocks, and that the lowest sediments are weak sandstones and sandy limestones, which greatly favored the stripping off power of the ice. Robert

Bell[1] has noted similar conditions in Canada and he says that when the ice sheet moved from the crystallines against the edges of the unaltered sedimentaries "great erosion has always taken place and valleys and basins are formed whose width depends upon the angle of dip and the softness of the strata which have been scooped out. The strata are presented in the most favorable attitude for abrasion. The wearing down would go on till the resisting rock front had attained a hight and weight sufficient to counterbalance those of the glacier." In the Black river valley the ice moved from the crystallines against the slightly upturned edges of the sediments.

In much the same way the soft shales were stripped off the surface of the hard limestones to form the broad terrace and the steep front of Tug hill. Such a stripping off of the shales occurred, but to a less extent, over the southern part of the Port Leyden quadrangle and the western part of the Remsen quadrangle. The maximum thickness of shale thus removed was probably several hundred feet, but not over a wide area. The total amount of shale removed was not nearly as much as may at first sight be supposed. Then too the shales were soft and highly jointed even to a considerable depth as may now be seen in the Whetstone gulf section.

Two other factors which greatly aided the work of the ice in the Tug hill region must not be overlooked. One of these is the fact that the ice moved up hill as it advanced southward along the valley and so had its cutting power increased. On reaching the divide between Black river and West Canada creek the cutting power was lessened and till and other drift materials were deposited in great quantities as the ice moved down hill toward the Mohawk river. Another factor which the writer regards as important in this connection is the angle at which the ice current entered the Black river valley in its sweep around the Adirondacks. The greatest amount of erosion was along the eastern side of Tug hill, and it is just here where the ice current must have struck with greatest force as it crowded into the valley. In harmony with this idea is the fact that the glacial striae near Martinsburg bear more toward the south than does the steep front of Tug hill.

It may be fairly asked, what became of the materials thus removed? The very resistent Precambrics ought to be present in considerable force somewhere in the region as erratics and this is the case southward especially in the townships of Boonville and Remsen where vast numbers of such erratics may be seen. Shale

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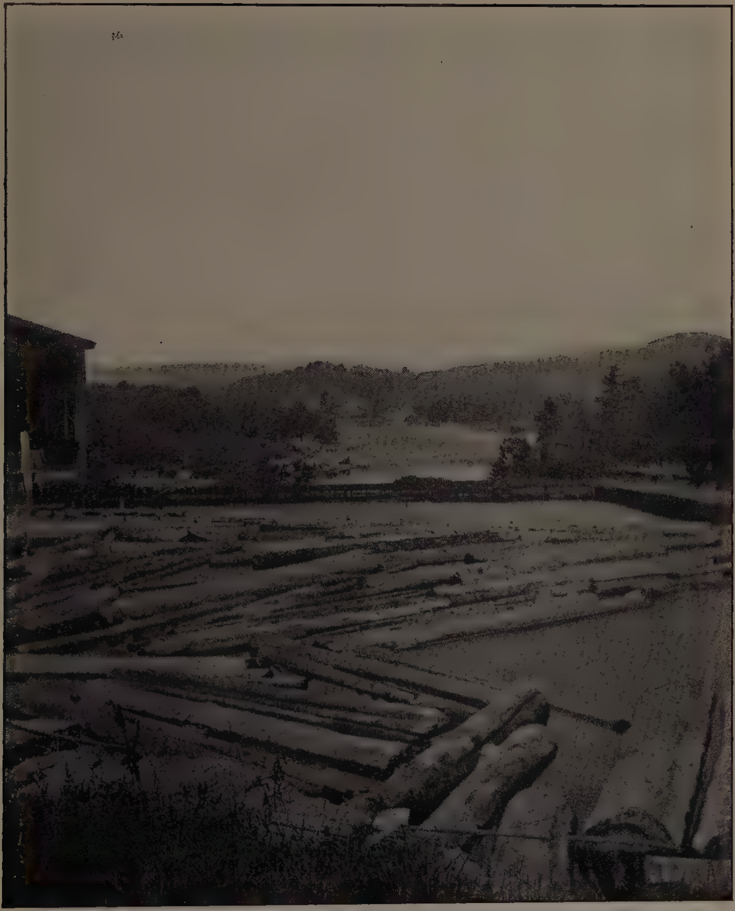
[1] Geol. Soc. Am. Bul. 1890. 1:296.

Plate 10



W. J. Miller, photo

Looking down Moose river from Goulds Mill. The river here, between Goulds Mill and Lyons Falls, flows through a drift-filled channel.

and limestone are also present in great abundance in the till and other drift of the Remsen quadrangle. However, much of the shale must have been ground up and carried away by glacial waters.

Glacial sand plains or terraces

A remarkable development of glacial sand plains or terraces is to be found within the Port Leyden quadrangle. Here, on the east side of the river, most of the region is occupied by these terraces, which taken together may be looked upon as a single great terrace with steep front facing Black river [*see* fig. 5]. On the Port Leyden sheet alone they cover fully 75 square miles and continue both northward and southward from this area. They are clearly shown upon the topographic map. The sands and gravels of these terraces show a depth of from 200 to 250 feet along the western edge, and there is a gradual thinning out to disappearance several miles eastward.

Except in a few cases the flat-topped surfaces are practically destitute of large boulders. A characteristic feature is the presence of pitlike or kettlelike depressions over the surfaces [*see* map]. These depressions are of various sizes and shapes and are sometimes occupied by lakes or ponds, as for example Brantingham, Little Otter and Catspaw lakes and Sand pond. They are often very steep-sided and range in depth from a few feet to 50 or 60 feet. The terraces are dissected by many streams so that enough good sections are exposed to make it certain that the materials are crudely stratified and cross-bedded, and occasionally interstratified with clay, thus proving that they were water laid. The western margin of this great terrace is distinctly lobate in character and is strongly suggestive of delta origin as for example in the southeastern part of the quadrangle. Another very notable feature is the concordance of altitudes at about the same distance back from the margin. The altitudes vary from about 1150 to 1260 feet, the higher altitudes being on the east, thus giving a gradual slope of the terrace surface toward Black river.

A study of the character and distribution of these terraces as well as their relation to the other drift deposits, leaves no doubt as to their origin as delta deposits in a marginal lake along the waning ice tongue during its retreat from the Black river valley. The immense amount of material thus deposited was readily obtained by the streams, especially Black and Moose rivers and Otter creek, as they emerged from the newly drift-strewn Adirondack highlands.

That they were deposited along the ice margin is clearly established by the presence of kames and large drift boulders along the western edge which prove an ice contact front here. The gradual downward slope of the sand plains toward the west is to be accounted for by the gradual lowering of the marginal lake level as the ice retreated.

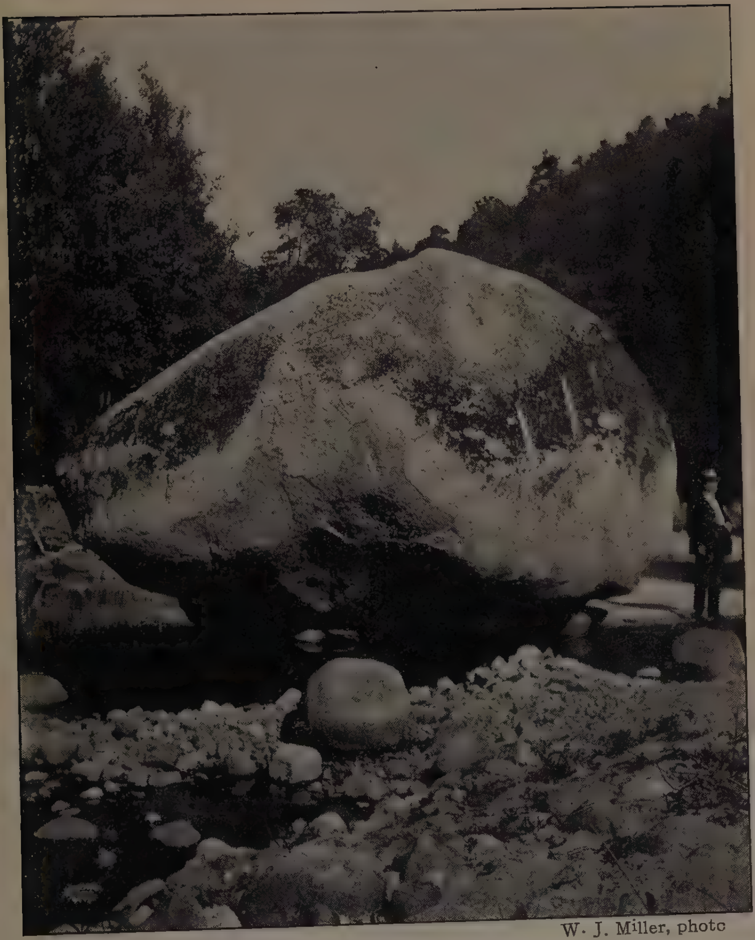
The depressions within the sand plains may be explained in either one of two ways. They may have been due to isolation of ice masses from the ice margin (possibly sometimes as icebergs) which were partially or completely buried under the delta sand to be melted later thus causing the development of the depressions, or they may have been due to unequal deposition of the delta materials whereby some places were not brought up to the general level. The depth, steepness of sides and irregular shapes of the depressions cause the writer to favor the first view to account for most of them.

Kames

Kames, which are hillocks of crudely stratified materials deposited at the ice edge, are rather abundantly represented except on the east side over the sand plain area. There is no group of large kames such as those of Park and Sperry hills within the Boonville quadrangle, or like those of the Remsen quadrangle described in a former report. Probably the best example of a single kame is the one ¾ of a mile southeast-south of Greig. It is remarkable for its steepness and symmetry of form and shows a hight of at least 150 feet. Many kames are located along the steep western front of the great sand terrace above described, especially from Lyons Falls northward. Other good examples may be found from south of Port Leyden to north of Lyons Falls along the railroad; south and west of Talcottville; along the road from Turin to Houseville; south and east of Martinsburg; and even on the highland southwest of Mohawk hill. Frequently, as in the locality last mentioned, there are long low ridges of stratified materials called eskers associated with the kames.

No doubt kames were also formed over the region now covered by the sand plains, but as the ice gradually retreated from the valley the kames formed along the ice edge were buried under the deep delta deposits. Only those along the western margin of the great delta deposit were left uncovered. Partially buried kames in the midst of a sand plain are finely exhibited around Forestport on the Remsen quadrangle. The sands are there comparatively

Plate 11



W. J. Miller, photo

An erratic or glacial boulder of syenite in the bed of Black river 2 miles northeast of Boonville. The boulder is about 27 feet across and 17 feet high and rests upon Black River limestone.

thin and after the formation of the kames and withdrawal of the ice edge, the delta sands were deposited around them but not with sufficient depth to cover them.

Erratics

Like the kames, glacial boulders or erratics are scattered over all parts of the quadrangle except the typical sand plains. Their absence from the sand plain belt is to be explained in much the same way as the absence of the kames, that is after the boulders were dropped by the melting ice they were covered by the delta deposits so that they are scarcely ever seen except along the larger stream courses where they have again been exposed by erosion. A good many are present along the western front of the delta terrace particularly in the vicinity of Greig. They are also strewn over the Paleozoic rock area, even on the high land of Tug and Mohawk hills.

The erratics are mostly from the hard, resistant Precambric formations and, as above pointed out, their presence on the high western portion of the quadrangle strongly argues for a southerly or southwesterly ice current at one time. The largest erratic observed by the writer is one of quartzose syenite, already referred to, which rests upon the Black River limestone about 2 miles northeast of Boonville. This boulder measures about 27 feet across and 17 feet high. Another large one may be seen in the field about ¾ of a mile east-northeast of Denley station.

Glacial lakes

A very interesting and extensive glacial lake occupied all of the sand-flat country on the east side of Black river between Forestport and Lowville. It also extended somewhat west of Black river in the vicinity of Boonville, and to an unknown distance north of Lowville. The former presence of this large lake is conclusively shown by the great development of unquestioned delta deposits, associated with clays, and the remarkably concordant altitudes of the sand plains [*see* above]. These waters were impounded by the waning lobe of ice in the Black river valley. The kames and drift boulders along the western edge of the great delta deposit show an ice contact from there; also the absence of delta deposits on the west side of the valley, under Tug hill, shows that the lake did not extend that far west. Again the failure of any delta deposits to reach out to or across the valley bottom also argues for ice occupancy of the deepest part of the valley during the existence of the large lake. In his description of the deposits along the Connecticut river, Gulliver has noted similar features and argues that those deposits must have formed before the ice had completely melted from the valley.[1]

The highest water level in this lake was apparently something over 1300 feet at which time an outlet probably crossed the Black river-West Canada creek divide[2] near Honnedaga (Remsen sheet) and flowed southward toward Trenton Falls. Possibly the extensive sand deposits near the latter place were formed by this outlet, although West Canada creek may have contributed to their formation. Further retreat of the ice lobe down the Black river valley certainly opened an outlet southwestward past Boonville and down Lansing kill toward Rome causing deposition of the great delta deposits north of the latter place. This delta no doubt formed in Lake Iroquois or rather its broad outlet in the Mohawk valley. This outlet from the glacial lake affords a fine example of a "through valley" to use the term suggested by Davis. The preglacial divide was doubtless near Hurlbutville as shown by the widening of the channel both northward and southward from that place; by the existence there of a deep inner gorge; by the aggraded stream bottom north of Hurlbutville; by the fact that the present stream could not have cut the deep narrow channel north of Hurlbutville and by the right elevation of an outlet there. The lake stood at approximately the 1250 foot level when it started over this divide and it cut down the divide rapidly until the 1140 foot level in the lake was reached. By this time the ice tongue had so far melted as to allow an escape of the water northerly and northwesterly along the west side of the ice tongue and into Lake Iroquois near Watertown. These north moving waters have left the limestones just west of the river more or less waterworn and possibly some of the minor terraces were formed by them.

Another lower and very distinct lake level was a little below 800 feet and caused by still further ice retreat to allow an accumulation of water back of a barrier at Carthage. The river is still engaged in cutting through this barrier. This lake extended southward to Lyons Falls where it was very narrow. Between Lyons Falls and Carthage the river now shows a very low gradient and the winding stream is developing terraces through the old lake deposits of the valley bottom.

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[1] Am. Geol. Soc. Proc. 1907. 18:640.

[2] The rather recent land movements in the region are not considered. Thus the elevations given are comparative only, but they are not far from the actual lake levels which were doubtless lower.

Drainage

Black river and its tributaries. From Hawkinsville to opposite Denley, Black river is certainly out of its preglacial channel as shown by the gorge cut into the limestones. Its former course was probably about 2 miles eastward along the Paleozoic-Precambric boundary. Between Denley and Port Leyden it is practically in its old channel. Thence to east of Lowville the stream is somewhat west of the preglacial course due to the westward shifting of the Paleozoic-Precambric boundary by erosion during glacial times. It is doubtful if any of the tributaries of Black river, which cut through the delta deposits and into the Precambrics, follow their old channels because they have been superimposed upon the Precambric surface. Thus Moose river has cut through the deep sands and is now engaged in eroding a channel, with gorges and waterfalls, into the Precambrics.

Origin of the "gulfs." The deep gorges which have been cut through the steep eastern front of Tug hill, by tributaries of Black river, are locally known as "gulfs." The chief gorges are occupied by Mill, House, Whetstone and Atwater creeks and Roaring brook. Whetstone gulf which is perhaps the most interesting, is about 2 miles long and shows a depth of 300 feet [*see* pl. 9]. Its walls are very steep sided to almost vertical, especially in the upper end (narrows) where there is just room enough for the stream at the bottom and where erosion is now proceeding most rapidly. A section showing something like 700 feet of Lorraine and Utica shales is finely exposed in this gorge. The stream emerges from the "gulf" upon the broad limestone terrace.

During glacial times the shales were eroded back over the limestone for a considerable distance, and this caused the development of the steep eastern front of Tug hill. After the disappearance of the ice from the region, all of the east bound streams from Tug hill rushed over this steep slope and began to erode notches into its summit. These notches were rapidly deepened in the soft shales to develop the "gulfs," whose heads have since been cut back to their present positions. South of Tug hill the "gulfs" are not so well developed because the shales, with their preglacial channels, were not cut back by erosion to such a great extent.

ECONOMIC PRODUCTS

Soils

The principal industry of the region is farming and the success of that industry here, as elsewhere, depends not only upon the character and energy of the people, but also, to a large extent upon the nature of the soil. The Port Leyden quadrangle affords us a fine example of the dependence of agriculture upon the geologic formations. From the standpoint of fertility of soil, Black river divides the district into two portions which present a remarkable contrast. Eastward from the river the territory is mostly covered with deep sands and gravels which are generally unproductive. Occasionally along the stream bottoms or where some clay is mixed with the sand, the soil is of fairly good quality. The potato crop is best suited to this sandy soil. There are many deserted farms on this side of the river and apparently this section was most prosperous when lumbering was the chief occupation of the people and farming a secondary matter.

On the west side of the river where the geologic formations are chiefly limestones and shales, and where sands and gravels are sparingly present, there is a prosperous farming community. Here the surface is mostly strewn with glacial debris which is largely composed of ground up shale, sandstone, and more or less limestone, which is thus a rich and easily worked soil.

Building stone

Building stone of fine quality occurs in immense quantities within the map limits. The rocks most quarried for this purpose are the limestones of the Pamelia, Lowville and Black River formations, but especially the Lowville. Many large quarries have been opened up in these formations, the principal ones being located on the geologic map. Such stone was used in building the numerous locks of the Black river canal and then later by the railroad for bridge abutments. It now has a considerable local use, especially for foundations. The highly jointed and stratified character of the Lowville and Pamelia beds cause it to be readily accessible in layers of almost any desired thickness up to about 2 feet. The Lowville is a bluish gray, very fine grained, pure limestone, while the Pamelia is usually a whitish gray to pink, more or less sandy and impure limestone. The gray Black River limestone quarries out as a more massive stone. The most extensive quarries are between the mouth of Sugar river and Denley station.

Other good building stone is found in the Trenton limestone, especially the upper portion. This rock is gray, coarse grained, crystalline, and pretty pure and may be quarried in layers from a few inches to a foot thick. The stone is much used locally and was formerly burnt in great quantities for the production of lime. The chief quarries are at Talcottville, Turin and Martinsburg. The sandstones of the upper Lorraine are strewn over the highlands on the west and are of considerable local use.

Of the Precambric rocks, the syenite is an excellent building material. It is a very hard, greenish to reddish, rather granitic syenite which takes a high polish. The expense of quarrying and transportation have almost entirely prevented its exploitation. A quarry from which syenite of fine quality has been taken is located about a mile east of Denley station.

Road materials

Most of the Precambric rocks, but especially the syenite, because of its great durability, when crushed would yield excellent road materials. Most of the stone now used for road work comes from the Lowville and upper Trenton limestones because this stone is cheaply quarried and crushed and is fairly durable.

Sand and gravel

As above explained much of the country east of the river is deeply covered with sand and gravel, often of good quality for all sorts of uses. The increasing demand for such materials will, in the future, doubtless cause the exploitation of these immense deposits.

Iron ore

In the above descriptions of the Precambric rocks, magnetite, in small grains, is seen to be very commonly present. Many times patches of magnetite 1 or 2 inches across have been observed in the mixed gneisses and in the more acid phases of the syenite and they have every appearance of being segregation masses. An ore body several feet across has been found on the Murtaugh farm 2 miles east of Glenfield. It is magnetite mixed with much pyrite and is closely associated with pegmatitic material in the granitic syenite. The pegmatite and ore seem to grade into the country rock and probably represent a segregation mass.

The most interesting and important magnetite deposits occur in the village of Port Leyden and on the west side of the river below the bridge. Many years ago several attempts were made to mine the ore here. An ore pit, now filled with water, was run down some 50 or 60 feet and a furnace was erected, but the mine was never a paying proposition. Ore was later brought to the furnace from other places. The ore is magnetite associated with much iron pyrites and often with quartz. A thin section of the ore from the pit shows 50% of quartz; 45% of magnetite and pyrite and 5% of badly decomposed ferro-magnesian minerals. The wall rock from the pit shows 35% of feldspar, chiefly microperthite and some oligogclase; 45% of quartz and 20% of biotite, pyrite, sillimanite, zircon and garnet. Thirty feet from the ore pit, the feldspar content is somewhat higher and the dark minerals not so prominent. Still farther away the rock is much like a quartzose syenite. A few rods from this pit and at the water's edge, an irregular shaped ore body several feet across may be seen. It is nearly pure magnetite and entirely surrounded by syenite. The ore is in no sense sharply separated from the country rock. A rapid but perfect gradation of the ore into the syenite may be seen and the evidence seems conclusive that this small ore body, at least, is a segregation mass in the syenite. The ore in the pit is thought to have a similar origin, although the evidence is not there quite so conclusive. This ore is closely associated with syenite and garnetiferous gneisses in a syenite-Grenville area and it is interesting to note that the Salisbury Iron Mine described by Cushing on the Little Falls quadrangle, and the occurrences noted by the writer on the Remsen quadrangle, all show similar relationships to the country rock. It would seem that when the molten syenite was passing through the Grenville the conditions were somehow made favorable for the segregation of the magnetite.

Lead ore

Before the middle of the last century lead ore was discovered in the Trenton limestone about a mile a little west of north of Martinsburg. The early attempts to mine the ore and extract the metal failed because of the small quantity of ore available. The ore is galena (sulphid of lead) which occurs in true vein deposits and associated with calcite as a gangue material. The calcite is frequently crystallized in six-sided prisms capped by three-sided pyramids. The vein-stuff fills joints in the limestone and the galena has doubtless been dissolved out of the surrounding rock and deposited in the veins.

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New York State Education Department

New York State Museum

JOHN M. CLARKE, Director

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1904. 138p. 20c.
1905. 102p. 23pl. 30c.
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1907. 212p. 63pl. 50c.
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In 1898 the paleontologic work of the State was made distinct from the geologic and was reported separately from 1899–1903. The two departments were reunited in 1904, and are now reported in the Director's report.

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12 (1892)	$.50	17	$.75	21	$.40
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Report	*Price*	*Report*	*Price*	*Report*	*Price*
1	$.50	10	$.35	18 (Bul. 64)	$.20
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5	.25	12	25	20 (" 97)	.40
6	.15	13	*Free*	21 (" 104)	.25
7	.20	14 (Bul. 23)	.20	22 (" 110)	.25
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9	.25	16 (" 36)	.25	24 (" 134)	.35

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Botanist's annual reports 1867–date.

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3 Economic Geology
4 Mineralogy
5 Entomology
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7 Economic Geology
8 Botany
9 Zoology
10 Economic Geology
11 "
12 "
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14 Geology
15 Economic Geology
16 Archeology
17 Economic Geology
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28 Botany
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